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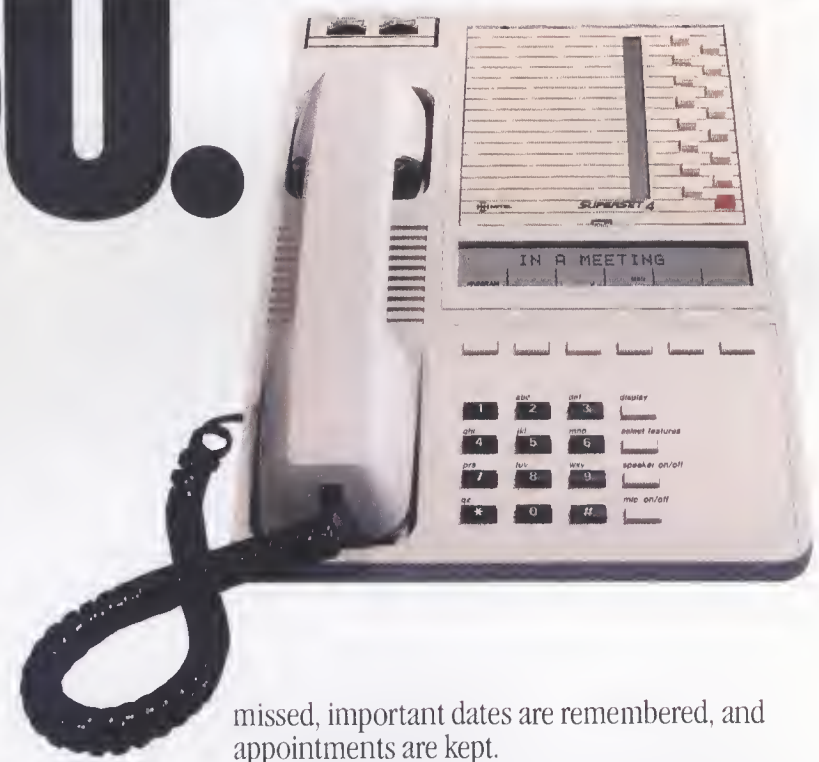

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A composite material made of graphite epoxy is ideal for use in space because it is stronger than steel yet lighter than aluminum. Unlike metal, it does not expand from exposure to heat or cold, and its reduced weight translates into lower costs and larger payloads. For example, saving just one pound in a space vehicle means a reduced launch cost of several thousand dollars or added fuel for longer operations. Until now, however, graphite composites have proved difficult to mold to shapes more complex than a simple cylinder. But research and development by Hughes Aircraft Company has opened the way for the fabrication of a variety of new forms, including tubes with integrated end fittings in a one-piece design, support beams, and ring structures up to seven feet in diameter.

The HR-3000, a new generation version of the Hughes Air Defense Radar (HADR), can detect and precisely locate fighter-sized aircraft more than 470 kilometers away. The phased array radar is designed for air traffic control in peacetime and can automatically detect wartime threats that appear simultaneously from several directions, even in the presence of heavy environmental clutter and severe electronic interference. The HR-3000 system is in full production at Hughes and will be used in Portugal and integrated with Hughes-built NATO Air Defense Ground Environment (NADGE) in Italy, Greece, and Turkey.

Upgraded flight simulators will depict mission imagery realistically for U.S. Navy F/A-18 pilots. Hughes is modifying its Weapons Tactics Trainers (WTT) to project high-resolution, full color, real-time simulated images of terrain features and man-made structures on 360-degree field-of-view dome screens that surround the trainer's cockpit. The out-the-window scenes will be produced by advanced computer imaging technology, using a digital database that represents 70,000 square miles of western Arizona and southern California terrain. The new simulated visual system will allow pilots to safely practice a host of complex combat scenarios without expending fuel or weapons.

An aircraft collision avoidance function is part of the new air traffic control system in the Republic of Korea. One of the world's most sophisticated civilian air traffic control (ATC) systems warns controllers when aircraft fly in converging paths, descend below a safe altitude, or approach restricted airspace. Radar data and flight processing functions are automated and combined in the system, enabling controllers to move traffic safely and expeditiously. The system monitors data simultaneously from multiple overlapping radar networks, creating a tracking picture significantly more reliable than current systems. When a potential conflict is identified, the system automatically provides an early visual and audio alert on the air traffic controller's console. Under development for three years, the ATC system and the aircraft collision avoidance function were both developed and built by Hughes. The system provides complete control of South Korean airspace, including en route and airport approach control throughout the nation and over ocean areas.

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SEPTEMBER 1987 VOL. 7, NO. 9

HIGH TECHNOLOGY BUSINESS

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DEPARTMENTS

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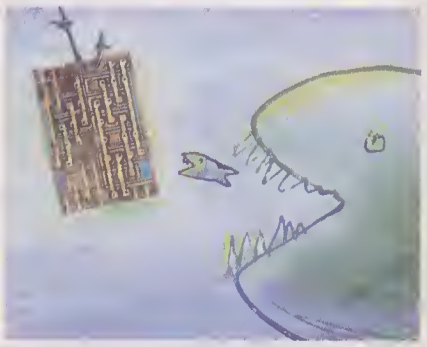

Chip companies: the hook is baited p. 20

Strict standards push software business p. 43

New cards carve out fresh markets p. 35

Cover photograph by George Steinmetz

Technology Meets Business

WITH THE addition of the word *business* to the title HIGH TECHNOLOGY on this month's cover, we have changed our name to HIGH TECHNOLOGY BUSINESS. Our coverage of technology has expanded and broadened and the magazine has upgraded its look, starting with the name and new logo on the cover.

Our mission is still to cover the latest developments in technology, with special emphasis on the companies and the marketplace in which the technology is being introduced. We identify the players affecting developing technologies to help you tell which companies are most likely to succeed.

HIGH TECHNOLOGY BUSINESS has added several new columns and departments, as well as a sharpened business focus in feature stories.

The *New Developments* section has been expanded to address more issues and trends. For example, this month's topics range from the companies behind the hand-held scanners used by Federal Express and Emery, to the latest advances in plastic engines.

We introduce three new columns: *Japan Watch, Computers,* and *The Law.* Also new this month is a section called *Market Watch,* which has several parts. *New Companies* notes the latest startup high-technology companies, including their backers, their products, and background on company principals. In *Mergers and Acquisitions* you'll find out who has bought whom. *Joint Ventures* describes which companies have combined efforts and why. *Contracts Awarded* lists the winners of high-technology contracts.

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But our objective remains the same—to give you the information edge for the information age. Having that edge should help you profit by making informed corporate decisions or financially rewarding personal investments.

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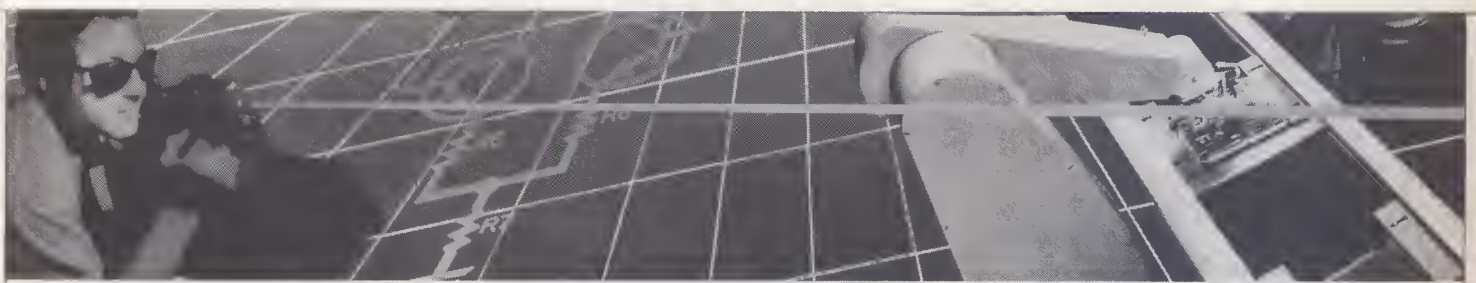

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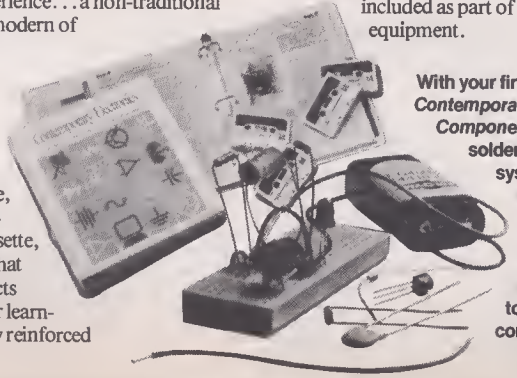

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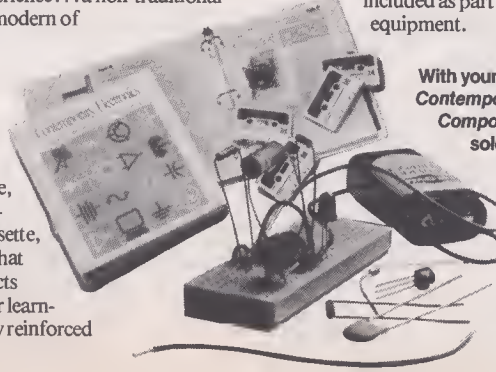

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LETTERS

■ Superconducting Possibilities

I HAVE DELIGHTEDLY observed that recent editions of your magazine have contained items of particular relevance to my interests; your article on superconducting is exceptionally so. This excellent piece perceptively and in detail links and interrelates the new superconductivity discoveries with the vaunted Superconducting Super Collider (SSC) project.

The SSC project should not proceed as planned by the Department of Energy, using the obsolete current design based on old superconducting technology. Instead, efforts should be first focused on accelerating R&D efforts on the new superconductors to the point of commercialization, and use the fruits of these efforts to redesign and construct the SSC. It is folly to encourage further development of existing superconductivity technology when it is apparent that the newly developing science offers far greater potential. Delay of the SSC for a few years to ensure incorporation of this new science is justified under these circumstances.

In sum, let's use government funding now targeted for the SSC to accelerate the creation of technology from the sensational new superconductor science. Time enough to build the SSC when this first priority is accomplished.

David Allen Roth
Kingwood, Texas

THE DISCOVERY OF materials that allow superconductivity at relatively warm temperatures opens the possibility of using the earth's magnetic field to propel earth-orbiting spacecraft.

Inasmuch as the earth is surrounded by a magnetic field, it should be possible to develop large amounts of electric energy in a spacecraft by means of wires made from these new materials. Using new developments in materials for creating magnetic fields, it may be possible to generate large enough magnetic fields that can oppose or be attracted to the earth's magnetic field to serve as a means of propulsion.

I realize that this is a far-out supposition, but one hopes that someone in the Defense Department is investigating this possibility. It would seem to have application to the SDI satellites.

E.J. Bataille
Walnut Creek, California

■ GE Part of Camcorder Market

REGARDING THE article on camcorders in your July 1987 issue: The author made a rather glaring omission in talking about companies in the camcorder market—the RCA and GE contribution! According to the March 30, 1987, issue of *Television Digest,* which ran a camcorder market-share survey, RCA is the number-one-selling brand in the U.S. with 18 percent of the market, and GE is tied for third at seven percent. Both brands, owned by General Electric, therefore account for one out of every four camcorders sold in America.

Judy Fleming,
Manager, News and Information
GE/RCA Consumer Electronics,
Indianapolis, Indiana

■ Home Movies

ABOUT YOUR article in June 1987 on new film technology: The fact that revenues of a billion dollars a month for the videotape-rental and pay-TV industries have not cut into movie-theatre box-office receipts can be interpreted in two ways. First, being able to see movies from start to finish without commercial breaks may have reawakened in potential moviegoers the realization of just how good movies are when they are seen without interruption. Second, those huge video and pay-TV receipts point up what an incredibly lousy job movie studios and exhibitors have done in selling their product in its traditional venue—the movie theater.

Come back in five years. Ten million homes will have a big-screen projection television with surround-sound and some form of higher-than-broadcast-definition system. I'm betting the future improved delivery of taped and filmed programming will take place in the home, not in the movie theater.

Jack Frost, Projectionist
Oakridge Cineplex Cinemas
Vancouver, Canada

■ Better Ways to Teach Engineering

RE: "MORE SCHOOLING for Tomorrow's Engineers," which appeared in the July issue of your magazine:

Clearly the present ways of engineering education are inadequate and must be changed. However, restraining the engineer from entering industry for one more year is not the right direction.

The way to improve engineering education is to expedite access to practical engineering experience, not delay it. Maintain the meticulous defining of theories, but prove the relevancy of each theory by showing how it will be applied to real future problems. (Educators will say that this is now practiced, but recent graduates report otherwise.)

Do not assign problems that degenerate into practice of the mechanics of problem solving. Assign real-world problems that demonstrate the importance, not just the use, of the theory. Reduce the significance now given to finding *the* answer. Coordinate and integrate with industry. Bring working engineers with real problems into the classroom. Send the students (not just the professor) into industry to view real problems and to participate in their solution. (Not a co-op program. The students must do engineering, not filing.) Show them how professional engineers must apply engineering judgment, and expose them to the effects of budget and schedule constraints.

Include courses on business communications, technical writing, and project management. Add short courses on business management and economics.

The term should not be longer, but the activity should be more intense. We need productive (experienced) engineers, not naive (student) engineers. History shows that the former is attained by exposing the latter to the real engineering business world. We either teach them now, or teach them later.

Roger L. Summers, P.E.
IR&D Technologies
Dayton, Ohio

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New Developments

Issues, products and advances that help create new opportunities for high-tech businesses

Scanners Seek More Delivery Deals

BACK WHEN Federal Express decided to equip its army of package-delivery drivers with bar-code scanners, it asked Handheld Products to design "something with eight kilobytes of RAM that's smaller than a baseball bat," recalls Handheld's marketing director, Jeff Osborne. The result is the palm-sized bar-code scanner and microcomputer that has suddenly become a common sight in offices using overnight couriers.

Drivers scan bar-code identification labels on packages as they pick them up, and enter additional information such as the name and address of sender and receiver. Additional scans during transit and upon delivery build a complete history for each parcel. Back in their trucks, drivers set the scanners into communications cradles that store entries. Federal Express even transmits the data back to the truck's terminal, giving managers instant reports on the activities of their fleets. Eventually the data gets fed into a central mainframe computer, where it's available system-wide.

Federal Express uses Supertracker, a customized version of Handheld's Microwand scanner. Handheld, based in Charlotte, N.C., got the contract two years ago, and by year's end all 16,500 Federal Express drivers will be equipped with Supertrackers, which cost about $1,000 each.

Computerized bar-code scanners are attracting buyers among package-delivery companies.

Telxon of Akron, Ohio, in January received a $3.5-million contract to supply Emery with a scanner system. The system, now in full operation, consists of more than 3,000 Telxon 620 PTCs (Portable Teletransaction Computers).

The trade group Automatic Identification Manufacturers estimates that the parcel-delivery market for hand-held scanners stands at $20 million. The market has not grown as quickly as expected, but the industry remains optimistic, cheered by such indications as United Parcel Service's test of a scanner system. "It's just a question of when other package-delivery companies will begin to use the scanners," says George Goldberg, publisher of the industry newsletter *Scan*.

Tiny Beads Clean Industrial Waste

COMBINING magnetism with biology, Cape Cod Research of Buzzards Bay, Mass., is licensing a new technique for recycling valuable materials and filtering hazardous wastes. The company impregnates tiny magnetized plastic beads with microorganisms to create magnetic biosorbents. The beads are then dumped into liquids that contain waste. The microorganisms selectively latch on to elements to be removed from the solution; magnets then gather and remove the beads.

According to Cape Cod Research, this advance may open new markets for companies that can produce and supply the biosorbents to manufacturers. The beads may be used to remove low levels of radioactive waste or traces of heavy metals from mining and industrial waste streams. In the United

STEVEN MARK NEEDHAM

States alone, industry spends $5 billion annually on the removal and treatment of hazardous and toxic waste, an amount expected to double by 1990. The relatively low cost of the beads ($200/ton) combined with the ease of removal may also make them suitable for rapid cleanup of accidental spills of hazardous substances.

Plastic Engines Go Commercial

TWO CANADIAN entrepreneurs are getting ready to commercialize a small gasoline engine made of plastic. If this engine does all its makers claim, it may radically change the market for low-horsepower engines—a market that consumes 32 million units in North America every year.

The Plastic Engine Technology Corp. (Petco) of Kingston, Ontario, has come up with a design that lets its two-stroke engines run cooler. As a result, they can be made largely of injection-molded plastic. In addition to being lightweight, the plastic components come out of their molds true to shape, and thus do not need expensive machining. This cuts production costs by 70 percent per engine, claims Petco. Therefore a Petco engine used for, say, a portable weed trimmer (three million of them are sold each year) is expected to sell to manufacturers for $50; conventional engines start at $90.

Petco was founded by President Gerry McKendry and Vice President Lee Tilley in 1985. Tilley says Petco is currently negotiating with several manufacturers who may use the engines in their products. "By April 1988 we'll be mass-producing five engine types," he says.

Paralysis Treatment Hits the Market

SEVERAL YEARS AGO, a potential breakthrough in the treatment of paralysis aired on *60 Minutes* and was the theme of a TV movie. A team at Ohio's Wright State University had demonstrated that electrodes fired by computers can cause paralyzed muscles to move, raising hopes that people with spinal-cord injuries might walk again.

Now, Computerized Functional Electrical Stimulation machines are being manufactured and marketed by Therapeutic Technologies of Alpha, Ohio. Paralysis victims pedal the exercisers; a microcomputer receives feedback from sensors in the machine and controls the electrodes' firing.

Two systems are available. The $36,500 REGYS I (Rehabilitation Exercise Gym System) is most commonly used in hospitals under a doctor's supervision. The $18,800 ERGYS I, which is suitable for home use, can be controlled by a handicapped person. The company has sold about 125 ERGYS machines after nearly 18 months on the market, and about 65 REGYS models since December 1984.

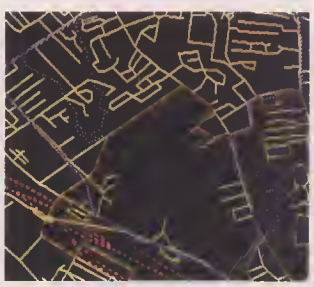
WILLIAM HUBER

Paralyzed muscles move again, with the REGYs exerciser.

The machines have not taken off as quickly as Therapeutic had hoped. Because the technology is so revolutionary, insurance companies have been slow to approve treatments using the machines, says a company spokesman. In response, Therapeutic set up its own office to process insurance claims. The company expects better acceptance of electrical muscle stimulation as more insurers are exposed to it.

Computer Maps Spot Sales Trends

A NEW GEOGRAPHIC-analysis program lets businesses merge their databases with digital maps. Designed for personal computers, the Map Information Display and Analysis System, or MIDAS, displays specific street addresses from the user's data, creating an electronic "pin map." A real-estate broker, for instance, may use the system to display locations of available two-story houses priced from $145,000 to $150,000. The system also provides printouts.



MAP INFO

Computer maps help business.

Developed by Mapping Information Systems of Troy, N.Y., the $750 software package can be purchased with digital maps for more than 300 metropolitan areas. The maps cost $300 to $2,000 apiece.

MIDAS can also track geographic trends. For example, a retailer could pinpoint neighborhoods in which many of its steady customers live. It could then tailor an advertising campaign to the area.

The company already has sold MIDAS to civic planners, cartographers, researchers, sales managers, and professionals in such governmental arenas as public safety and transportation, according to Sean O'Sullivan, MapInfo president. For example, a New Jersey survey firm uses the system to index completed surveys and reduce duplication of effort.

MIDAS can be used on an IBM PC or compatible personal computer.

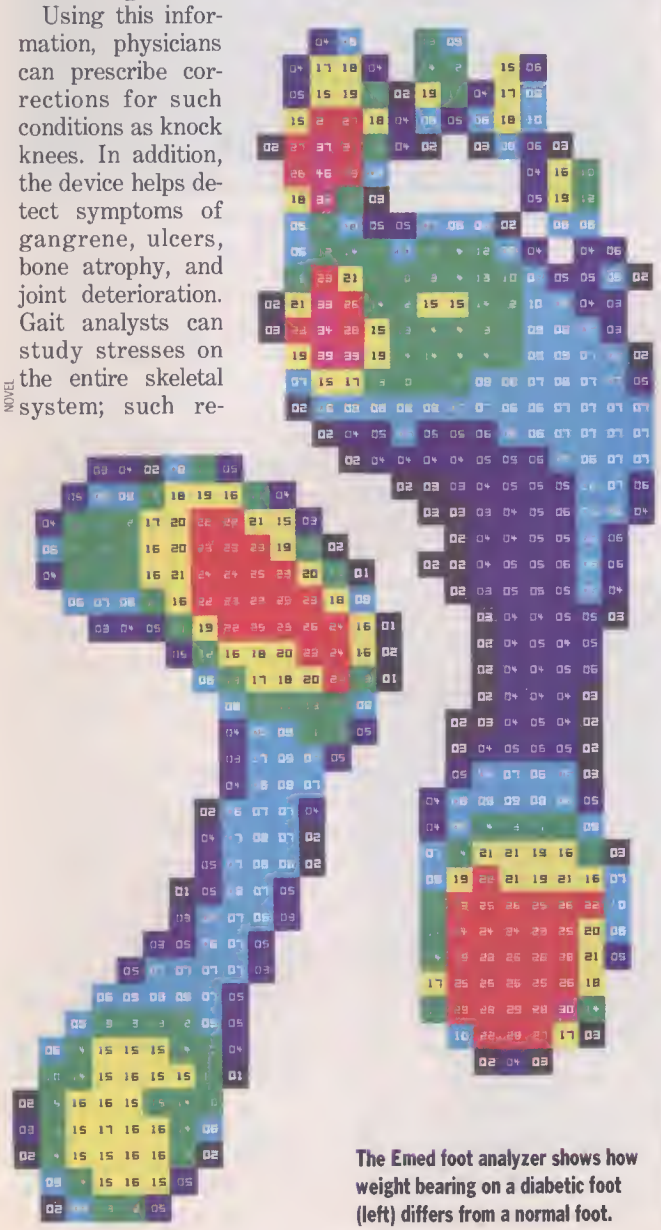
Sensors Analyze Foot Ailments

ATHLETES as well as people who have foot problems may want to seek out the Emed System, a computerized device that measures pressure under the foot. Sensors in the system's measuring platform gauge the load; a sensor insole in a shoe may also be used. The computer displays a color-coded chart that indicates where weight falls.

Using this information, physicians can prescribe corrections for such conditions as knock knees. In addition, the device helps detect symptoms of gangrene, ulcers, bone atrophy, and joint deterioration. Gait analysts can study stresses on the entire skeletal system; such research could lead to advances in joint replacement and prosthesis design.

Another promising application is in sports medicine. Emed can show athletes the best shoe design for a particular activity, and ski-boot makers can create better designs that minimize injuries.

Novel, a company in Munich, West Germany, has sold at least 27 Emed systems internationally to clinics and hospitals, universities, and shoe manufacturers.



NOVEL

The Emed foot analyzer shows how weight bearing on a diabetic foot (left) differs from a normal foot.

GTE

New transistor wafers may mean a new business for GTE.

Silicon Wafers Cut Processing Costs

RESEARCHERS at GTE's laboratory in Waltham, Mass., have developed a new way to make silicon chips that can be used for transistors—those ubiquitous power-switching devices that find their way into a host of electrical appliances. The discovery may lead GTE into the transistor business.

With conventional methods, electric connectors are implanted onto the surface of silicon wafers used in transistors. However, GTE adds the metal tantalum disilicide to molten silicon before it is formed into silicon bars. When the bars are sliced into wafers, the wafers have microscopic metal threads running through them.

The company claims that transistors formed by this process can handle higher power because the connections run the whole thickness of the wafer. Also, the built-in threads reduce processing costs because connectors do not have to be added—a step that requires clean-room conditions, GTE claims.

What's more, the new silicon chips are sensitive to light, important in such applications as electronic cameras, optical communication systems, and solar-energy equipment.

A GTE spokesman says the company is currently studying whether to license the new process or produce transistors itself.

Another Printer Takes on Lasers

LASER PRINTERS have unseated daisywheel and dot-matrix printers in many businesses. Now other page-printer technologies are challenging lasers for a piece of a market that's expected to grow by more than 40 percent this year, with a total of 420,000 printers sold.

The latest entry is the CrystalPrint VIII by Data Technology of Santa Clara, Calif. Like other page printers, CrystalPrint deposits text and graphics on a rolling drum that transfers them to the page. But instead of using a laser to put the image on the drum, a row of tiny liquid-crystal shutters are opened and closed by a microprocessor to admit light from a fluorescent lamp.

Such new entries face an uphill struggle. Hewlett-Packard's LaserJet line owns more than 80 percent

MEDICHROME

ts on eye drops.

currently testing its duct on animals, and begin human tests year. The company completed an $84- imited research and ment project with Vebber. Amgen re- rights to market its "The biggest obsta- face will be demon- its clinical applica- ays Dr. Philip Whit- mgen's director of planning. "This is nous opportunity." ■

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track of tele-flo- sactions among Teleflora of Los has designed the stem, a business ion of CD-ROM discs with read- nory). For $2,150 /month lease), flo- a personal com- d software. The disks carry a directory of florists in Teleflora's 1,800-shop network, enabling users to locate other subscribers and identify their services. The system also indicates the number of times another shop has sent the florist business.

Mathmatica of Lakeland, Fla. Tested and certified by the University of Miami's School of Architecture, the program turns a computer drawing of a building, combined with a photograph of its proposed construction site, into a video image of

matica developed the software in collaboration with the university. The company expects to sell about 7,000 copies this year, priced from $5,000 to $10,000.

■ Small companies that want to do independent market research, and oth-

field, Shamrock's $395 Peoplefacts program helps people create questionnaires. The program helps devise questions and set up the form. When a larger questionnaire is necessary, the Survey System from Creative Research Sys-

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NOVEL

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of the wafer. Also, the built-in threads reduce processing costs because connectors do not have to be added—a step that requires clean-room conditions, GTE claims.

What's more, the new silicon chips are sensitive to light, important in such applications as electronic camera a laser to put the image on the drum, a row of tiny liquid-crystal shutters are opened and closed by a microprocessor to admit light from a fluorescent lamp.

Such new entries face an uphill struggle. Hewlett-Packard's LaserJet line owns more than 80 percent

of the market, and Apple Computer's Laser Writer, about 15 percent. But Data Technology's director of strategic planning, Michael Sugihara, points out that the market's 40-percent growth rate is expected to continue for the forseeable future, opening up new territory for latecomers.

A price war may be brewing. With the least expensive page printers, such as one from Okidata, hovering around $1,200, a push is on to bring out a model priced under $1,000. Rumor has it that Hewlett-Packard will have such a price leader by year's end. Data Technology may beat its larger rival, however. Sugihara says the company plans to introduce a broader spectrum of liquid-crystal-shutter models within about six months.

Genetics Companies Find Healing Protein

HUMAN TESTS of a naturally occurring protein that may help wounds heal faster are beginning. Food and Drug Administration approval for the protein, called epidermal growth factor (EGF), is expected within two years, and widespread availability of the protein should follow within five years. During that period, EGF may become the preferred treatment for burn victims. Animal trials show that the protein doubles the rate of skin regeneration with no visible side effects; it also aids in cornea regrowth. In a report released earlier this year, the consulting firm of Arthur D. Little said EGF by 1990 will become a standard for healing surgical incisions. If EGF cut one day off the average hospital stay for each of the more than 21 million surgical patients treated annually, savings would total $4 billion.

One EGF manufacturer, Creative Biomolecules of Hopkinton, Mass., is beginning tests on humans this fall and is shopping for outside distributors.

Last October Chiron of Emeryville, Calif., began human tests of EGF eye drops to treat cornea abrasions. Chiron has signed a major marketing and development agreement with Ethicon, a Johnson & Johnson subsidiary. William Anderson, Chiron's vice president of finance, forecasts that its EGF product will capture 40 to 60 percent of the projected $1-billion annual market.

Amgen of Thousand Oaks, Calif., is currently testing its EGF product on animals, and plans to begin human tests within a year. The company recently completed an $84-million limited research and development project with Paine Webber. Amgen retains the rights to market its product. "The biggest obstacle we face will be demonstrating its clinical applications," says Dr. Philip Whitcome, Amgen's director of strategic planning. "This is an enormous opportunity." ■

MEDICHROME

Biotech bets on eye drops.

ALSO WORTH NOTING

IMAGE TRANSFORMATION LAB

An architect's computer drawing (left) becomes a detailed site simulation with image-processing software.

■ Architects and designers stand to make better aesthetic judgments, attract clients, and appease zoning boards by using image-processing software from Mathmatica of Lakeland, Fla. Tested and certified by the University of Miami's School of Architecture, the program turns a computer drawing of a building, combined with a photograph of its proposed construction site, into a video image of the facility. Because the images are generated from digital data, they can be electronically manipulated to show the building from different vantages. Mathmatica developed the software in collaboration with the university. The company expects to sell about 7,000 copies this year, priced from $5,000 to $10,000.

■ Small companies that want to do independent market research, and others who conduct surveys, can now get lower-priced survey software from San Diego's Shamrock Press. Like other computer programs in this growing field, Shamrock's $395 Peoplefacts program helps people create questionnaires. The program helps devise questions and set up the form. When a larger questionnaire is necessary, the Survey System from Creative Research Systems of Petaluma, Calif., can handle up to 32,000 questions. Survey software is attracting an expanding market from such corners as marketing, customer service, large organizations, catalogers, and consultants.

■ To keep track of tele-florist transactions among shops, Teleflora of Los Angeles has designed the DoveSystem, a business application of CD-ROM (compact discs with read-only memory). For $2,150 (or a $70/month lease), florists get a personal computer and software. The disks carry a directory of florists in Teleflora's 1,800-shop network, enabling users to locate other subscribers and identify their services. The system also indicates the number of times another shop has sent the florist business.

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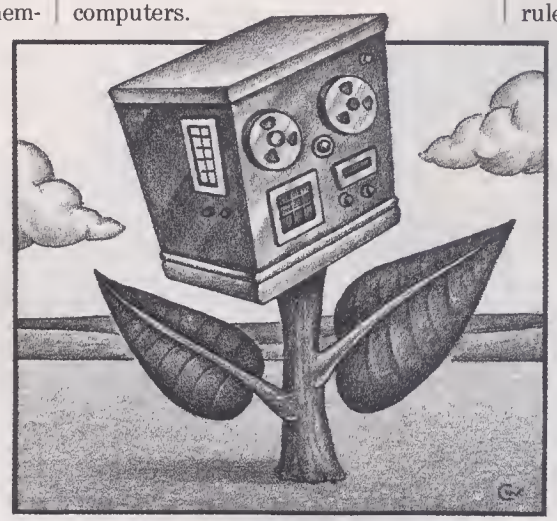
Rethinking the Mainframe

SELLERS' RECENT WOES HOLD MANY LESSONS

■ **By Clinton Wilder**

THE GREAT COMPUTER Industry Slump of 1985-86 continues to fade in the rearview mirror for most leading manufacturers of large mainframes and midrange minicomputers. But as computer-system sellers try to recapture the growth rates of the early 1980s, they find themselves in an industry that has fundamentally changed.

The transition in the mainframe-computer business can be traced through the acronym coined in the 1960s to describe IBM's competitors—the BUNCH: Burroughs Corp., the Univac division of Sperry Corp., NCR Corp., Control Data Corp., and Honeywell, Inc. By the beginning of 1987, that moniker could arguably have been reduced to UC. But the U has a new meaning and the C—Control Data—has yet to sustain consistent profits after two years of losses.



CHARLES WALLER

What happened? Burroughs acquired Sperry and renamed the combined entity Unisys Corp. NCR has essentially forsaken the mainframe business and now focuses on transaction processing for the retail and financial industries, and on minicomputers. Honeywell sold most of its computer business at a bargain-basement price to a joint venture called Honeywell Bull. Except for the federal-government computer unit it retained, Honeywell now develops and sells all of its computers through Honeywell Bull, which is owned by Honeywell, majority partner Compagnie des Machines Bull of France, and NEC Corp. of Japan.

Two pervasive trends among business computer users precipitated the breakup of the BUNCH. The first was a buying slowdown brought on by lower corporate capital spending, tax-reform uncertainty, and "indigestion" from the technology-buying binge of the early 1980s. The second trend has been a change in the way corporate America performs data processing. Variously known as the microprocessor revolution, distributed processing, or the rise of end-user computing, this trend has grown out of the advanced chip technology that squeezes more computing power into much smaller and cheaper computers.

Even though IBM and most of the BUNCH companies (particularly Sperry and Honeywell) offered a minicomputer product line, their corporate focus and philosophy centered on mainframe processing. The competitive-technology battles were fought over speed, as companies touted faster, more powerful computers with better price/performance ratios.

But the combatants often failed to address customer needs for better communication between systems, better links to personal computers, and the ability to run the same software on several systems.

Mainframe companies suffered. For example, IBM saw its revenue from processors and related peripherals, most of which was mainframe-related, drop 17% between 1984 and 1986.

As the computer industry continues to climb out of the slump, the computer-system makers best positioned for business success are those wisely following these fundamental changes. IBM, through product announcements ranging from the 9370 midrange computer to the Personal System/2 microcomputer, is sending the message that it recognizes the changes in the world it has ruled for years.

Not that mainframes will disappear; a Paine Webber Inc. survey of 31 *Fortune* 500 companies earlier this year found that buyers plan to increase their mainframe capacity by an average of 20% to 30% annually. But increasingly, such machines will serve as the host for networked minicomputers.

Digital Equipment Corp., IBM's foremost competitor in the past 18 months, continues to dazzle the industry with systems in which all components can run the same software without modification. More than any other major systems company, DEC has ridden the small-is-beautiful, transaction-oriented computing trend to success. The company's revenues for the nine months that ended March 29 were up 24% from the same time a year earlier; profits also doubled.

As the computer business heads toward a position as the world's largest industry before the end of the century, it can look back on the past two years as a significant course correction. The trend toward different roles for mainframes will strengthen the industry in the long run, but companies that fail to heed that trend will undoubtedly pay the price. The fate of the once-mighty BUNCH—losses, consolidations, and overseas joint-venture spinoffs—should serve as a powerful lesson. ■

Clinton Wilder is a senior editor and columnist for the computer-industry section of Computerworld.

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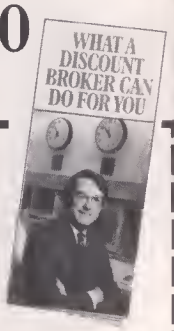

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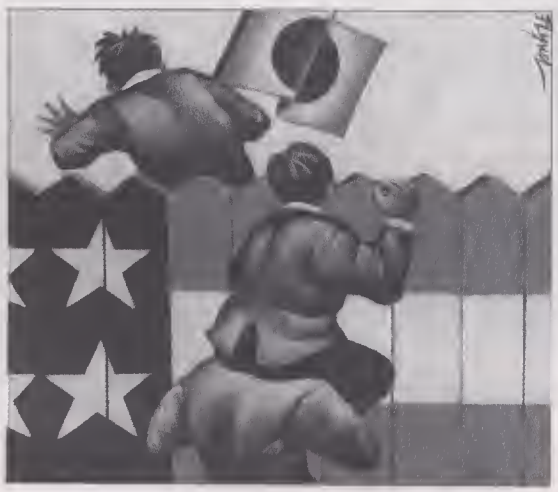
TRADE BARRIERS PROMPT JAPAN TO MOVE FAST

■ **By Kent Bowen**

THE WORLD ECONOMY has changed. Commodities no longer dominate trade; today, such factors as technological knowledge and practice determine the competitive edge. Advanced materials, the catalysts of new products and processes, figure prominently in the world of the future.

The Japanese have responded to this change perhaps better than anyone by applying advanced materials not only to high-tech products, but also to the manufacturing processes of the major basic industries. One example: the new high-temperature superconducting materials, which promise to revolutionize electrical and electronic technologies.



FRED LYNCH

During a recent international conference in Japan on advanced materials, I spoke with academic and industrial leaders from Japan and several other nations. Academicians from leading Japanese universities expressed a deep commitment to keeping Japan at the forefront of superconductivity. Immediately after Tokyo University's duplication of the major breakthrough in superconductive research at IBM's Zurich lab, Professor Shoji Tanaka of Tokyo University warned his colleagues that scientific leadership must be maintained, or Japan would again be accused of being "only implementors, and not creators, of science."

While the academic community strives to sustain a leadership position in superconductivity science, Japanese businessmen have decided they must be first in the patent race.

Sumitomo Electric provides an example of this aggressive approach—the company has reportedly applied for more than 400 Japanese patents on ceramic superconducting devices, processes, and compositions—equivalent to about 60 U.S. patents. The race to develop proprietary or protected technology may involve as many as 100 Japanese companies, which may be joined by about 20 national or regional government-supported laboratories.

Japanese efforts focus on early commercialization. Because of the potential economic impact of superconducting ceramics, Japan's Ministry of International Trade and Industry (MITI) has commissioned a planning study, and has also pushed to obtain commitments from industry and government to start a major program. However, the major manufacturers of superconducting cable, electronics, and advanced materials feel the commercial promise of these materials is too great, and the early commercialization and development of proprietary technology too critical, to be encumbered by the bureaucracy of a MITI program. Even so, my Japanese colleagues believe MITI will eventually establish a major program. This slowly evolving effort for a major MITI-sponsored superconductor program with Japanese industry should not be confused with programs already underway at the numerous MITI research labs scattered throughout Japan.

The research activities of U.S. corporations differ significantly from those of Japanese companies. Except for such corporations as IBM, AT&T, Du Pont, and GE, few U.S. companies have been able to commit substantial resources to superconducting materials.

Unlike superconducting-cable companies in the U.S., seven major Japanese cable-manufacturing companies have the resources to be involved in the ceramic-superconductor business: Hitachi, Toshiba, Sumitomo Electric, Mitsubishi Electric, Kobe, Furakawa, and Fujikura. Electronics companies working on superconducting devices include NEC, Hitachi, NTT, Fujikura, Sanyo, Sony, and TDK. Many of these companies also have substantial technical and production resources in the area of ceramics.

Japanese companies have been leaders in commercializing high-tech ceramics, and there is no reason to believe they will move slowly to commercialize the new superconducting ceramic materials. American companies may not reap all the possible benefits from advanced materials because they appear to be incapable of finishing the job of rapid commercialization.

The real or imagined economic pressures currently affecting U.S. companies have created forces counter to the broad development of advanced materials for many non-defense and non-aerospace markets. Makers of devices and systems should recognize the importance of advanced materials to a company's competitive strategies, and appreciate the need to share with materials suppliers both the development costs and value added by such materials. ■

Kent Bowen is professor of materials science at the Massachusetts Institute of Technology.

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MEETING LICENSING DEMANDS CAN KILL SMALL COMPANIES

■ **By Anne Simon Moffat**

MEDSENTRY MAKES tiny water beds that could help save the lives of premature babies. An air pump sloshes water around in irregular wave patterns, simulating conditions inside the uterus and presumably easing the newborn's adjustment to the world. The novel water bed fits in standard incubators.

The product may not make it to market, however. The small company, run by the husband-and-wife team of Larry and Sue Browne in Santa Barbara, Calif., faces a financial crisis. The company licensed the technology the product uses from Stanford University, and the small startup (last year's sales: $62,000) cannot afford the liability insurance that Stanford is demanding as part of the licensing arrangement.

MARK KSENIAK

Such conundrums are not unique. Idec, a company in La Jolla, Calif., that is developing an antibody-based cancer therapy that uses Stanford research, almost hit the same dead end. The licensing deal was saved only after the university, which normally requires its licensees to have $5 million in insurance when they do clinical trials, agreed to be satisfied with the $500,000 insurance that the company could get.

The spectre of liability litigation has dampened the enthusiasm of many universities for licensing deals—a trend that threatens to cut small companies off from what has been a fertile source of new products. Particularly hard-hit are the high-risk arenas of medical equipment and pharmaceuticals. The liability issue is arising with greater frequency as universities increasingly conceive products in those fields and attempt to commercialize them. Even though the business that markets a product would be named in any liability suit, the plaintiff usually goes after everyone related to the product involved, and a wealthy licensor makes an especially juicy target. Top-notch research universities like Stanford and the Massachusetts Institute of Technology worry that their endowments, often amounting to hundreds of millions of dollars, will come under attack.

As a result, businesses that want to turn university research into profitable products are running into increasingly stringent demands from the universities. Those demands often create a Catch 22 for licensees: they can't get the technology unless they meet university demands, but meeting university demands may leave them financially unable to develop and market the product.

The insurance that universities require can kill a company before it gets going. Because many high-tech fields have no track record on which insurance companies can base risk estimates, insurance rates can be exorbitant—as much as $90,000 for $400,000 of protection.

Businesses also must sometimes deal through a middleman rather than directly with the school. For example, University Patents Inc. of Westport, Conn., specializes in taking title to patents and negotiating with prospective licensees. Although this arrangement appeals to some companies because it lets them negotiate with another business rather than an academic bureaucracy, the involvement of a middleman adds cost.

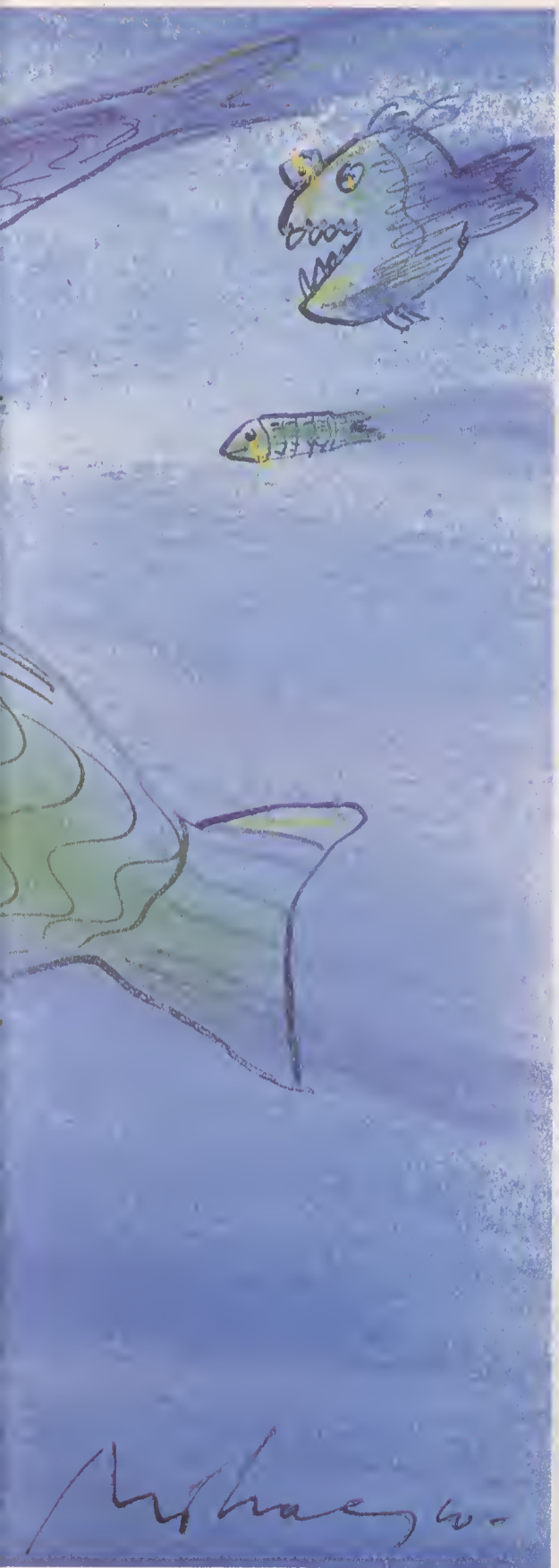
Universities also try to protect themselves from litigation by licensing concepts rather than products and barring an inventor from further involvement—financial or otherwise—in the company. From a business perspective, such a requirement can be an advantage; it's generally cheaper to license a product at a very early stage of development. The catch is that a company may be deprived of the inventor's expertise.

"Some sanity to tort law is needed to give entrepreneurs—and universities—a fighting chance," says John Preston, MIT's director of technical licensing. Until recently, there was hope that new legislation might stem the tide of liability suits and ease the commercialization of research by putting a time limit on claims and by eliminating licensors from liability, except in cases of clear negligence. But this year's juggling of congressional committees dimmed that prospect: The chairman of the Committee on Commerce, Science, and Transportation is U.S. Senator Ernest Hollings, an outspoken advocate of trial attorneys. Few expect the present Congress to change the law.

In the meantime, the small firms that have hit snags because of universities' fear of litigation are trying to find their own solutions. Says MedSentry's Sue Browne: "We are seeking to be bought out, hoping that a larger company can afford the insurance we need to continue doing business." ■

Anne Simon Moffat is a free-lance writer.

EUGENE MIHAESCO



Chip Takeover Targets

The companies most likely to be acquired

By Michael R. Leibowitz

Watch your step, Seeq Technology, Xicor and Micron Technology. Look out, California Devices and GigaBit Logic. The great semiconductor shakeout has begun, and according to a HIGH TECHNOLOGY BUSINESS survey of industry analysts and CEOs, you are the chipmakers most likely to be shaken out in the next 12 months.

THE FIVE TAKEOVER TARGETS*

1. Seeq Technology
2. Xicor
3. Micron Technology
4. California Devices
5. GigaBit Logic

*Based on a HIGH TECHNOLOGY BUSINESS survey.

Seeq, a technologically advanced but financially weak maker of reprogrammable memories, emerged as the clear favorite of the 34 respondents to the confidential poll. Seeq was named by 19 respondents, putting it well ahead of second-place California Devices, which received 15 mentions, Xicor (14), Micron Technology (13), and GigaBit Logic (13). Rounding out the top ten were Silicon Systems, Waferscale Integration, Bipolar Integrated Technology, Applied Micro Circuits, and Integrated Device Technology.

The tally produced no big surprises for industry watchers. The young companies that placed among the top five each

5 possess a hot technology and a hunger for capital that simply won't quit. Each chipmaker has either found itself up against the giant Japanese conglomerates or has seen its research costs skyrocket.

All suffered tremendously during the worldwide semiconductor recession of 1985 and 1986. At present valuations, each would make a great buy for a fellow chipmaker or a good customer. All that's needed is some extra cash—and deep pockets to finance the fledgling's future growth.

But these five are only a small part of a much bigger story. A series of recent events—the closing of Honeywell's Synertek subsidiary in 1985, the 1986 attempted purchase of Fairchild Semiconductor by Fujitsu of Japan, and the 1987 merger of France's $436-million Thomson Semiconductor with Italy's $375-million SGS Microelectronics—signal the start of a period of worldwide consolidation among semiconductor companies. The chip business is in "the first 10 percent" of a wave of consolidation that will crest within the next three years, says Bill McClean of Integrated Circuit Engineering (ICE), a chip-industry consultant. Jack Beedle, president of In-Stat, another market-research company, concurs; he predicts that the next five years will bring a "massive restructuring" of the semiconductor industry.

Those who say consolidation is imminent argue that to play the semiconductor game, a company must be either very big or very small. A big company can afford the manufacturing and R&D to compete against the Japanese and Koreans. A small company can concentrate on market niches too small to interest the major semiconductor suppliers. The companies in the middle will get squeezed.

"There is going to be a no-man's land," says Daniel Hutcheson, head of VLSI Research, an industry consultant. Hutcheson and others believe this forbidden zone lies between $100 million and $1 billion in annual sales.

The first to go will be the small chipmakers that may have carved out market niches but are financially troubled and unable to attract financing. "Many companies are at the edge," says ICE's McClean. Most of the acquisitions of small companies with less than $100 in annual sales will occur during 1989–90, McClean predicts. Later, some of the larger companies may take their turn on the block, as they too find the public-capital markets less receptive to their need for more money to expand and modernize.

Who will buy all these troubled chipmakers? Key prospects include other chipmakers that see the acquisition as an ideal way to strengthen their own market positions. Industry experts surveyed by HIGH TECHNOLOGY BUSINESS. point to the top five U.S. chip houses—Texas Instruments, Motorola, Intel, National Semiconductor, and Advanced Micro Devices—as ones that would benefit by acquiring smaller companies.

Siemens, the West German conglomerate, is also frequently mentioned as a company to watch. European industrial leaders feel a certain paranoia about their delay in entering the semiconductor business, according to E. Lawrence Hickey, an investment analyst with First Analysis. With more than $7 billion in its coffers, Siemens has the means to become a major player.

Many analysts believe that the Japanese industrial conglomerates, if allowed, would gobble up one U.S. chipmaker after another. Such activity would deepen the Japanese companies' U.S. market penetration and isolate them from the fluctuating value of the yen. However, analysts do not expect much bidding by Japanese companies soon. Continued trade frictions and the Commerce Department's quashing of Fujitsu's proposal to acquire Fairchild Semiconductor have sent the Japanese an unmistakable signal: cool your heels.

The customers for chips—manufacturers of electronic systems—are the other main prospects that might try a takeover. Systems houses have already found that forging close alliances with certain chipmakers can give them a competitive edge in gaining proprietary chip designs that reduce the cost of their products. Owning a chipmaker also assures a source of supply.

However, not everyone believes the industry will consolidate. "The assets in the industry are the designers," says Andrew Kessler, an analyst with Paine Webber. "When a company gets acquired, the good people leave and go start another one."

Indeed, virtually all the semiconductor acquisitions of the 1970s and early 1980s have resulted in disaster. Fairchild, Mostek, Signetics, Zilog, American Microsystems, and Intersil have floundered since their acquisition by large electronic-systems makers. Three of these chipmakers have found themselves up for sale again. "The parent company has to throw so much capital at the business that they get sick and tired of it," says Kessler.

T.J. Rodgers, president of Cypress Semiconductor, one of

HOW THE SURVEY WAS DONE

To determine the most likely takeaver targets among U.S. semiconductor companies over the next year, HIGH TECHNOLOGY BUSINESS conducted a manth-long survey. We polled the chief securities and market-research analysts who specialize in the semicanductor industry; in addition, we also asked chief executive officers of semicanductor companies to participate in the survey. A questiannaire mailed in June listed the names of 45 chip companies and asked respondents to check the names of companies they felt were likely takeaver candidates within the next year. The mailing was fallawed by telephane calls to thase wha did not respand initially. Participants were pramised confidentiality. The five companies profiled in this repart received the most votes.

Anadigics
Bear Stearns & Ca.
Birr Wilsan Securities
Calagic
Crugnale & Assaciates
Eberstadt Fleming
ECI
Fairchild Semicanductor
First Analysis
First Boston
Faxboro/ITC
Hambrecht & Quist
Integroted Circuit Engineering
International Microcircuits
ITT Semicanductors
Janney Montgomery Scott
Kidder Peabody
L.F. Rothschild
Ladenburg Thalmann
Lattice Semiconductor
Menla Ventures
Merrill Lynch
Micro Lineor
Montgamery Securities
Nomuro Securities
Paine Webber
Pershing & Co.
Precision Monolithics
Seidler Amdec
S.G. Warburg
Silicon Systems
VLSI Technalogy
Wertheim & Co.
Xylinx

PRIVATE CHIP COMPANY PROFILES

COMPANY	ADDRESS	PRESIDENT	SALES ($M) 1986	1987 PROJ.	FOUNDED	PRODUCTS
Applied MicroCircuits	5502 Oberlin Dr. San Diego, CA 92121 (619) 450-9333	Roger Smullen	17	29.5	1979	Semicustom integrated circuits
Bipolar Integrated Technology	1050 N.W. Compton Dr. Beaverton, OR 97006 (503) 629-5490	George Wilson	NA	6	1983	Digital signal processors, technical computing products
Californio Devices	1051 S. Milpitas Blvd. Milpitos, CA 95035 (408) 945-5000	Douglas Ritchie	10	13	1978	CMOS gate arrays, application-specific integrated circuits (ASICs)
Dallas Semiconductor	4350 Beltwood Pkwy Dollos, TX 75244 (214) 450-0400	John Smith	13.4	32	1985	Nonvolatile memories, telecommunications products, microprocessors
GigaBit Logic	1908 Oak Terrace Lane Newbury Park, CA 91320 (805) 499-0610	John Heightley	Under 5	NA	1981	Digital integrated circuits made from gollium orsenide
Hypres	175 Clearbrook Rd. Elmsford, NY 10523 (914) 592-1190	Sadeg Faris	NA	NA	1983	Superconducting electronics
Internationol Microcircuits	3350 Scott Blvd., Bldg. 36 Santo Clora, CA 95054 (408) 727-2280	Fronk Deverse	11	14	1972	Custom integrated circuits from gate arrays ond standard cells
International Microelectranic Products	2830 First St. San Jose, CA 95134 (408) 432-9100	Barry Corrington	29.2	50.6	1981	ASICs, mixed onalog/digitol circuits
Micrel	1235 Midos Woy Sunnyvale, CA 94086 (408) 245-3500	Ray Zinn	10	12	1977	Radiation-hardened integrated circuits
Precision Monolithics	1500 Space Pork Dr. Santo Clara, CA 95054 (408) 727-9222	Dovld O'8rien	70	80	1969	Anolog ond dato-conversion products
Performance Semiconductar	610 E. Weddell Dr. Sunnyvole, CA 94089 (408) 734-8200	Tom Longo	NA	NA	1984	Logic and processor circuits
Saratoga Semicanductor	10500 Ridgeview Court Cupertino, CA 95014 (408) 973-0945	Ed Browder	NA	NA	1985	Integrated circuits combining CMOS and bipolar technologies
Sierra Semiconductor	2075 N. Capitol Ave. San Jose, CA 95132 (408) 263-9300	Jim Diller	8	25	1984	ASICs
TriQuint Semiconductar	8ox 4935 Beaverton, OR 97076 (503) 629-3535	Al Patz	NA	NA	1985	Custom foundry systems, stondord digital ond microwave components, semicustom ASICs
Universol Semiconductor	1925 Zonker Rd. Son Jose, CA 95112 (408) 436-1906	Vic Hejmadi	12	12	1981	Digitol gate orrays, semicustom anolog/digital arrays, dato-conversion products
Vitesse Semiconductor	741 Colle Plano Comorillo, CA 93010 (805) 388-3700	Lou Tomosetta	None	2-3	1984	Gallium-orsenide integrated circuits
VTC (formerly VHSIC)	2401 E. 86th St. 8loomington, MN 55420 (612) 851-5000	Tom Hendrickson	35	47	1984	Gate orroys, standard cells
WaferScale Integration	47280 Kato Rd. Fremont, CA 94538 (415) 656-5400	Sheldan Taylor	3.7	20	1983	Nonvolatile memories, ASICs

*NA=Not ovoiloble

SOURCE: MEDIA GENERAL FINANCIAL SERVICES/HIGH TECHNOLOGY BUSINESS RESEARCH

PUBLIC CHIP COMPANY PROFILES

Company (ranked by sales)	Symbol (market)	Annual sales (fiscal year-end) $M	Annual profit (loss) $M	Last-quarter profit (loss) $M	Change from same quarter last year %	7/21 close $	Stock price 52-week High $	Stock price 52-week Low $	P/E ratio	Financial position Last fiscal year Current ratio	Long-term debt $	Common stock equity $
Motorola	MOT (NY)	5,888.0 (12/86)	194.0	56.0	24.4	55.00	63.88	33.63	30.7	1.6	2.61	21.49
Texas Instruments	TXN (NY)	4,974.0 (12/86)	39.9	74.7	NE	61.38	67.59	34.25	41.5	1.6	2.49	22.49
National Semiconductor	NSM (NY)	1,478.1 (5/86)	(148.3)	3.9	NE	13.38	16.63	8.25	NE	1.6	1.36	7.91
Intel	INTC (OTC)	1,265.0 (12/86)	(183.3)	31.5	NE	47.00	49.25	16.63	NE	2.7	2.43	10.83
General Instrument	GRL (NY)	787.9 (2/87)	(80.4)	12.0	135.3	36.50	39.88	15.88	NE	1.6	5.62	14.35
Advanced Micro Devices	AMD (NY)	632.0 (3/87)	(95.9)	4.1	NE	17.25	24.50	12.88	NE	2.3	2.30	8.11
Analog Devices	ADI (NY)	334.4 (10/86)	23.4	4.7	(21.7)	20.75	23.88	14.25	50.6	2.7	0.66	6.15
LSI Logic	LLSI (OTC)	194.3 (12/86)	3.9	2.1	(22.2)	10.13	17.13	8.13	NM	8.7	2.71	6.37
VLSI Technology	VLSI (OTC)	111.7 (12/86)	0.1	1.9	850.0	14.88	18.88	8.75	62.0	3.8	1.28	5.99
Siliconix	SILI (OTC)	111.2 (12/86)	7.4	1.1	(50.0)	9.75	15.25	9.75	27.1	3.9	3.13	5.14
Silicon Systems	SLCN (OTC)	66.8 (9/86)	0.1	0.3	(62.5)	9.75	15.00	9.00	22.2	4.7	7.27	5.48
Integrated Device Tech.	IDTI (OTC)	57.7 (3/86)	3.2	1.1	450.0	14.13	16.63	6.63	67.3	3.6	1.13	4.37
Standard Microsystems	SMSC (OTC)	53.2 (2/87)	0.5	0.3	200.0	14.88	18.38	9.38	NM	6.5	0.40	7.79
Exar	EXAR (OTC)	52.5 (3/86)	4.4	(6.2)	(100.0)	10.00	14.50	8.00	NE	1.0	0.21	7.58
Cypress Semiconductor	CYPR (OTC)	50.9 (12/86)	7.3	1.9	72.7	11.88	13.50	6.75	44.0	4.5	0.60	3.34
Micron Technology	DRAM (OTC)	48.9 (8/86)	(33.9)	(3.8)	NE	12.00	13.50	3.50	5.3	3.4	1.17	3.73
Xicor	XICO (OTC)	44.3 (12/86)	(3.8)	0.9	NE	12.50	13.13	4.63	NM	1.3	1.12	2.28
Silicon General	SILN (OTC)	32.7 (6/86)	(6.6)	0.0	NE	3.63	5.50	2.88	51.8	1.2	0.84	2.93
Orbit Instruments	ORBT (OTC)	31.1 (6/86)	6.6	1.7	(10.5)	10.38	12.63	9.50	12.8	6.8	0.51	5.09
Seeq Technology	SEEQ (OTC)	30.5 (9/86)	(23.6)	0.7	NE	8.75	9.63	3.44	NE	0.6	0.73	(6.85)
Linear Technology	LLTC (OTC)	22.3 (6/86)	1.2	0.9	200.0	11.50	14.50	5.75	71.9	5.6	0.27	1.90

NE = Negative earnings NC = Not calculable NM = No meaningful figure

SOURCE: MEDIA GENERAL FINANCIAL SERVICES

the hottest of the 1980s crop of startups, also poohpoohs the consolidation forecast. "As far as I'm concerned," says Rodgers, "consolidation is a rumor the investment bankers are churning around to give themselves more merger-and-acquisition business."

But those who say the industry must consolidate point to some compelling pieces of evidence. One of these pieces is that economists say another recession is only 12 to 18 months away, and the present upturn is hardly the blockbuster that many chipmakers need to restore their health.

More fundamentally, the U.S. chip industry is maturing. The worldwide sales growth of the industry averaged only 18 percent over the last four years, compared with 34 percent between 1975 and 1979, according to Dataquest, the leading semiconductor market researcher. Dataquest pegs average growth over the next four years at only 14 percent.

Meanwhile, the U.S. market for chips has slowed even further. With the shift in the production of electronic equipment from the United States to the Far East, Japan eclipsed the United States as the major consumer of chips in 1986. But this fast-growing market, though potentially very lucrative, remains closed to most U.S. chipmaking companies.

At the same time, the cost to develop and produce chips will continue to skyrocket as the Japanese set a staggering pace for capital investment. The current price for the equivalent of an automated Japanese megaplant is $200 million. Such a facility can cut chip-manufacturing costs by as much as 30 percent.

After 30 years of negative cash flow, the U.S. chip industry must slow down. Gone is the glamorous image of the 1970s, says Matthew Crugnale of Crugnale & Associates, an industry consultant. The reality of the chipmaking business is that "it's a lousy investment for most people," says Crugnale. "The way you make money in semiconductors is to buy them and put them in your equipment—or buy and sell stock. That's why I think those who have the ultimate benefit from chips are ultimately going to seize the chip industry."

Most experts agree that the wave of consolidation will come when chip-business growth has slowed to a crawl. Periods of high growth in the chip industry have typically been driven by a boom in a certain product, such as video games in 1979–82 and personal computers in 1983–84. Thus, the big question facing the semiconductor business is, when will the next electronic equivalent of video games or personal computers come along to drive a U.S. chip-industry boom?

"That's always the problem," says industry veteran Gordon Moore, who as co-founder of Fairchild Semiconductor and later, Intel, helped make Silicon Valley the dominant force it is today. "It's hard to predict when these blockbuster trends are going to come along.

"As long as they keep coming, we're OK. I guess when we keep expecting one and it doesn't happen, is when the industry is going to show some signs of maturing." ■

WHO'S LIKELY TO BUY

A HIGH TECHNOLOGY BUSINESS survey of chip-industry analysts and chief executive officers asked which companies might acquire a chipmaker that falters. The companies most often mentioned were:

Siemens
Intel
Advanced Micro Devices
Ford Motor
LSI Logic
Motorola
Fujitsu

Survival Strategies: Chip Companies Shift Gears

Success will come to companies that understand—and obey—a radically changed set of market rules

By Michael R. Leibowitz

Early this year, U.S. makers of integrated-circuit chips won an 11th-hour reprieve from two years of losses and layoffs. Although sales fell 17 percent in 1985 and improved only slightly through most of 1986, a long-awaited boom in personal computers and computer workstations has brought modest growth—and long-lost optimism—back to the nation's chipmakers.

But the last downturn served chipmakers with a stern warning: change the way you do business, fast. The penalty for not doing so, they now realize, will be more trouble in the next downturn, which is forecast for 1989, and a possible future appearance on the sales block.

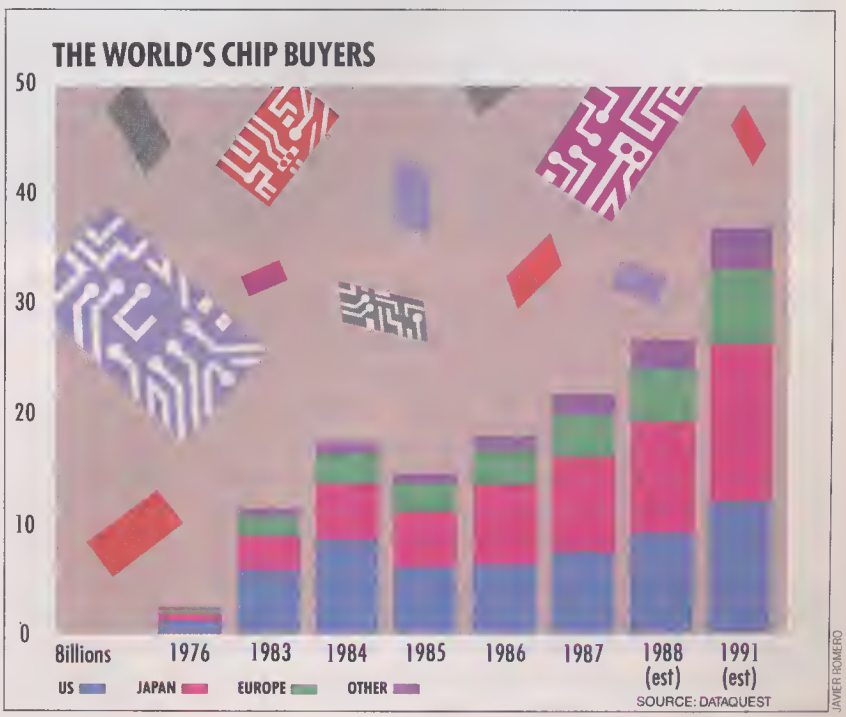
The chip-manufacturing business has changed drastically since the 1970s. Today's established chipmakers, many of whom launched their businesses with minimal funding of less than $5 million, rode steep waves of growth—as much as 25 to 50 percent in the best of the bounty years. Customers waited in line to pay handsome prices for the silicon slivers needed to keep their burgeoning electronic-equipment-manufacturing lines running.

Some U.S. chipmakers succeeded by designing proprietary products that turned into industry-standard best-sellers. Others produced huge numbers of identical chips—sometimes called "jellybeans" in the industry—such as memories.

Today, making money in the chip business is not so simple. The jellybean market has fallen under Japanese dominance. In 1986, according to the market-research firm Dataquest, Japanese companies captured 78 percent of the $2.1-billion worldwide market for dynamic random-access memories (DRAMs), the highest-volume product in the semiconductor industry. They also hold 92 percent of the smaller market—$450 million—for static random-access memories (SRAMs). The Japanese are fast overtaking the competition in other markets as well; they now hold 55 percent of the $910-million market for erasable programmable read-only memories (EPROMs).

It doesn't help matters that the medium-volume chip markets where U.S. semiconductor companies have held strong are splintering into a plethora of separate low-volume products. Long past are the days of making a company's fortune on just one best-seller such as a microprocessor. Also, thanks largely to a new wave of sophisticated computer-aided design tools, the focus of the industry-wide competition is shifting away from manufacturing and toward design. Since 1980, more than 100 startup companies have sprouted to produce specialized, proprietary chips for such low-volume, niche applications as digital signal processing and graphic displays. In addition, these startups, as well as the big Japanese and U.S. chipmakers, enable customers to buy customized chips, called application-specific integrated circuits, (ASICs).

Chip customers have embraced ASICs because they often eliminate gobs of standard-function chips, reduce the size of products, improve performance, and make products more difficult to copy. Dataquest reports that sales of ASICs, which totaled $4.9 billion in 1986, have more than tripled



SEEQ TECHNOLOGY

Restructuring and Revival

"We didn't go through all those hours turning this company around to become someone's subsidiary," says Seeq president and CEO J. Daniel McCranie.

McCranie has reason to bristle at the mention of acquisition. With fiscal 1987 revenues projected at $43 million and two profitable quarters under its belt, the six-year-old company is now returning to its original business focus on electrically erasable, programmable read-only memories (EEPROMs).

Because the EEPROM market grew far slower than anticipated, Seeq shifted in 1983 to making EPROMs (memory chips that are erased optically rather than electrically). By switching to these popular devices, the company drove sales from $9 million in 1983 to $43 million in 1984. But during the slump of 1985-86, the company found itself battling the Japanese with a product on which it had become dangerously dependent.

After venture capitalists forced out Gordon Campbell, Seeq's freewheeling founder, Seeq lost $37 million in fiscal 1985 and 1986 and laid off 35 percent of its work force. The company has since restructured, raised an additional $6 million in equity, and introduced a new set of products. Still, says McCranie, Seeq will need an additional $25 million to grow over the next three years.

J. Daniel McCranie

GEORGE STEINMETZ

The financial community has applauded Seeq's revival, bidding its stock up to $10 a share from a low of $3.44 in August 1986. But with a market valuation of about $100 million, Seeq is an attractive acquisition target. "Seeq is a likely candidate for a number of reasons," says Paul Johnson, an analyst with L. F. Rothschild. "It's in a good technology, the market is starting to expand, and the company is cheap.

"The problem is that McCranie has done such a good job that I don't think he wants to be bought. And a hostile takeover doesn't make sense in this business."

Would McCranie let Seeq be acquired? "We're not looking right now to be acquired," says McCranie, who has held Seeq's top position for 18 months. "But I will do what I honestly believe is best to keep this corporation alive."

AT A GLANCE

Founded 1981
Major products: Reprogrammable memories
1986 revenue: $30.5 million
1986 loss: $23.6 million
1849 Fortune Dr., San Jose, CA 95131
(408) 262–5041

since 1981, and are projected to grow 250 percent by 1991.

These changes call for new survival strategies for the established U.S. chip houses. Chipmakers must become experts in market niches to bolster their product portfolios with high-profit items and to avoid dependence on low-profit commodities.

Simultaneously, these companies have to expand and automate their production lines in order to compete effectively using their bread-and-butter products—medium-volume chips—which have met increasing international challenge.

Unfortunately, to maintain a presence in the medium-volume business, U.S. chipmakers must continue to produce and do battle in high-volume commodities. Top U.S. chipmaker Texas Instruments says it has no choice but to continue making DRAMs, although the company does not expect to make much money at it. The reason: the experience gained by churning out this ultra-high-volume device drives the company to develop technology that lowers the cost of making other products, says Jim Watson, a company vice president.

So important are high-volume products to fine-tuning the manufacturing process that four of the top five U.S. chipmakers say they intend to continue producing at least one commodity product in large quantities (more than one million units a week). The one major company not following this strategy—National Semiconductor—has been the driving force in trying to organize Sematech, a joint venture of U.S. chip manufacturers that would develop, refine, and share with all participants its high-volume manufacturing technology.

But other chipmakers are not counting on Sematech to act as a collective "manufacturing driver" for the U.S. industry. "I'm skeptical that it [Sematech] can accomplish what it sets

5

XICOR

A Return to Profitability

Experts chose Xicor as an acquisition candidate because, like arch-rival Seeq Technology, Xicor possesses an attractive technology centered around electrically erasable (EE) memories. Unlike conventional semiconductor memories, these devices retain their information even after power has been turned off.

EE memories show up in products that range from office facsimile machines, where they store telephone numbers for automatic dialing, to aircraft flight recorders. Falling cost and new uses, such as in "smart" credit cards, will drive the market for EEPROMs—electrically erasable, programmable read-only memories—from its present $55 million to $105 million by 1991, according to Dataquest, a research company. So far in the U.S., only Xicor and Seeq Technology produce a wide range of electrically erasable memories, and both stand to benefit from any boom market in them.

Xicor has a unique technology, says James Meyer, an analyst with Janney Montgomery. "If you want to have a foot in EEPROMs, and don't want to reinvent the wheel, then you want to go with the company that's gone farthest down the road—and that's Xicor."

Founded in 1978 by ex-Intel employees, Xicor had one profitable year—1984—before the industry-wide slump that cost the company $23 million in 1985-86. Unlike Seeq, Xicor weathered the downturn well; last April, it raised $22.5 million with a public stock offering, and in June completed its third consecutive profitable quarter. Analysts project Xicor will close 1987 with sales of $67 million, up from $44 million in 1986.

But Japanese competition looms ahead for Xicor, which depends on EE memories for virtually all of its revenue. Xicor plans to fight the Japanese by remaining one technological step ahead, says chairman and president Raphael Klein.

"At this moment, we are definitely not looking for any merger," says Klein. "We are happy just showing improvements in performance every quarter." But, he adds, "if there are historic trends that make sense, one would be stupid to stand against them."


Raphael Klein

GEORGE STEINMETZ

AT A GLANCE

Founded 1978
Major products: Reprogrammable memories
1986 revenue: $44.3 million
1986 loss: $3.8 million
851 Buckeye Court, Milpitas, CA 95035
(408) 946-6920

out to do," says Intel chairman Gordon Moore, one of the chip industry's pioneers. Intel, which has long specialized in proprietary chips rather than efficient production, will take its own steps toward becoming a "competitive, world-class manufacturer," says Moore. In the past two years, Intel has invested $210 million in capital equipment—much of it in manufacturing automation—and will continue producing the highly competitive, low-profit EPROM as its manufacturing driver.

Although major chipmakers still sell commodities, they are shifting emphasis toward niche products and ASICs. In 1982, Texas Instruments got less than 20 percent of its revenue from specialty products. Within five years, says vice president Watson, more than half the company's revenues should come from niche products and ASICs. National Semiconductor is walking the same path. Four years ago, 80 percent of its revenue came from commodities. National has pushed that number down to 60 percent, and the company believes it must decrease the commodity portion of its revenue still further—to less than 40 percent.

National drastically changed its organization to become customer driven, a key element in providing niche products and ASICs. It realigned its profit-and-loss units around chip markets rather than chipmaking technology. The company also replaced its sales force, which had consisted of manufacturer's representatives, with 90 company-employed sales engineers.

But as major U.S. chipmakers pin their future success on whipping their organizations into customer-driven machines, the kings of the customer-driven hill—the 1980s crop of startups—must start thinking about what they want to be when they grow up. To become more than tiny companies,

5

MICRON TECHNOLOGY

Taking Aim at the Japanese

Joe Parkinson

STEVE WELSH

"We don't believe in niche markets," says lawyer-turned-chip-manufacturer Joe Parkinson, chairman and CEO of Micron Technology. "If it's not a high-volume product, we're not interested in making it."

Joe Parkinson and his twin brother, memory-designer Ward Parkinson, have stuck to this strategy since forming the company in 1978 with funding from local potato tycoons. Micron makes dynamic random-access memories (DRAMs)—the highest-volume commodity chips in existence. With the exception of giant Texas Instruments, all other U.S. manufacturers have abandoned the DRAM market in the face of brutal Japanese competition.

Micron claims that its Boise location lets it build DRAMs at lower cost than any Japanese chipmaker. "As long as they don't dump," says chairman Parkinson, "we've got a gusher." But Micron, which is projected to close fiscal 1987 with sales over $90 million, has been battered by the continued low prices for DRAMs. The company lost a whopping $34 million in 1986 and spilled another $24.3 million in the first three quarters of fiscal 1987. Earlier this year, the company raised $13.8 million through a private placement with European investors. But Micron will need additional funds in 1988 to build a new chip-fabrication facility. This could cost $25–$50 million, says E. Lawrence Hickey, an analyst with First Analysis.

"I think they'd be hard pressed to raise more than $50 million," says Hickey. Other analysts believe that Micron, because of its low valuation and need for capital, is a likely takeover target for any Japanese or European company that wants to bypass the U.S. pricing restrictions by manufacturing DRAMs here. Also, any U.S. companies that abandoned DRAMs could, by acquiring Micron, jump back into the market, meanwhile taking advantage of Japanese production rollbacks.

Chairman Parkinson would not comment on whether another company might buy Micron in the next 12 months. "What you're talking about is all pie in the sky," says Parkinson. "We're in the acquiring business, not in the getting-acquired business."

AT A GLANCE

Founded 1978
Major products: Dynamic random-access memories
1986 revenue: $48.9 million
1986 loss: $33.9 million
2805 E. Columbia Rd., Boise, ID 83706
(208) 383-4000

experts say, the startups must begin bolstering their manufacturing capability to prepare for higher-volume markets.

Some of the startups spent half of their $30–$50 million in venture funds on a minifab—a low-volume fabrication facility that can turn out many different types of chips quickly, but far less efficiently than the bigger plants. Others, attracting only $8–$15 million to start their companies, do not have their own chipmaking plants; they operate as design houses, farming production out to silicon foundries, often in the Far East.

The problem arises as the startups see some of their niches grow, attracting the inevitable swarm of foreign and domestic competitors. Suddenly, these startups can find their chips too expensive to compete. LSI Logic, for example, was formed six years ago to attack the then-small ($136 million) market for gate arrays, an easily customized type of chip. Now, the gate-array business has mushroomed to $1.7 billion, according to Dataquest, and the niche has attracted 100 other companies, including the 11 major Japanese competitors. Even though LSI's sales have swelled to $194 million, the company is barely making a profit. LSI Logic has spent the past few years trying to figure out how to lower its manufacturing costs so it can stay competitive.

T.J. Rodgers, founder and president of four-year-old Cypress Semiconductor, sees a different future for his company. He says the answer to building Cypress to $350 million in sales is resisting the temptation to become dependent on one successful niche. The key to surviving a price attack by the Japanese, he says, is to occupy as many niches as possible.

But this may prove to be an unrealistic strategy. Charles Phipps, a former Texas Instruments vice president and now a chip-industry consultant, argues that Cypress, as well as

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CALIFORNIA DEVICES

Defending a Market Niche


Douglas Ritchie

GEORGE STEINMETZ

Douglas Ritchie, chairman and CEO of California Devices Inc. (CDI), spent the past year looking hard for someone to acquire or become a partner in his $10-million company. CDI lost money every year for the past three years, and Ritchie undoubtedly speaks for his investors when he says, "We're certainly not going to continue to put money into a losing proposition, ad nauseam."

CDI's story demonstrates what happens when the big boys invade your niche. Back in 1978, CDI attacked the nascent market for gate arrays—partially customized chips that replace many standard-function chips. CDI designed the circuits, then farmed out manufacturing.

The company was making money and virtually doubling sales every year through 1983. But by 1984, with the market for gate arrays approaching $1 billion, a swarm of Japanese and U.S. competitors had invaded CDI's market. In the guerrilla tactics of chip warfare, companies slashed prices and, in certain cases, offered to do CDI's business—chip design—for free in exchange for a large production order.

CDI decided to raise the money for its own production facility. Venture capitalists poured in $13.5 million and installed a management team. The company bought Storage Technology Corp.'s chipmaking plant at a distress-sale price of $6 million.

But CDI never revived. Although it raised an added $3 million a year ago, the company—now with a hungry fabrication plant to feed—is still losing money. The application-specific integrated circuit (ASIC) business—the broader market of which CDI's gate arrays form one segment—continues to be cutthroat.

"The Japanese are homing in on the ASIC business because it's more difficult to prove dumping charges," says Ritchie, a former National Semiconductor executive. CDI's strategy? "We're going to create a consolidated entity in some form," says Ritchie. CDI has been talking to other small chip companies about pooling resources, and with larger chipmakers about the possibility of being bought.

"We will do something," a determined Ritchie says. "We are not going to continue to lose money."

AT A GLANCE

Founded 1978
Major products: Gate arrays
1986 revenue: $10 million
1986 profit: Not available
1051 S. Milpitas Blvd., Milpitas, CA 95035
(408) 945–6123

other small niche producers, cannot expect to grow without attracting stiff competition to a major part of its revenue base. "It's either going to be a niche producer and stay in the $100–$150 million range, or it must gear up for a major product line," he says.

Cypress' Rodgers disagrees. His company has just brought up its second minifab and has no plans to build standard products. Rodgers intends to maintain the company's flexibility by spawning separate subsidiaries as new niches emerge.

Cypress may be the one startup that is successful enough to pull off an aggressive expansion. While Cypress made money during this past slump, many of its peers have seen their financial health languish.

But all chipmakers, big and small, face similar questions. How do companies whose financial performance has been shaky for years suddenly gain the resources and expertise needed to attack an increasingly fragmented market? (It can cost between $500,000 and $2 million to develop a new niche chip.) And what happens when the startup has used up the niches that launched it—and the new niches are outside the background of its founders? Other problems involve the increasingly global nature of the chip market, and the difficulty of producing chips economically when the cost of an automated fabrication plant has skyrocketed.

The solution, says Jack Beedle of the market-research company In-Stat, is "partner or perish." Indeed, "partnering" has become the hottest verb on the semiconductor scene. Within the past three years, virtually every chipmaker has built at least one strategic alliance, and some of the biggest companies have as many as 30. These alliances involve trades, joint ventures, and purchases of product

GIGABIT LOGIC

Hoping for a Revolution

GigaBit Logic is a pioneer in the great tradition of the semiconductor industry. The tiny, six-year-old company is building a business on chips made from a compound called gallium arsenide (GaAs)—an alternative to silicon that produces chips that work as much as 10 times faster than the speediest silicon circuits. For years, experts have been predicting that GaAs chips would revolutionize products from communications equipment to supercomputers. Some industry watchers had even forecast a billion-dollar business this year for these chips, which also have military and aerospace applications.

Like other pioneers, GigaBit suffered the consequences when the experts were wrong. GaAs chips turned out to be more difficult and expensive to make than had been thought; the material is extremely brittle, for example. GigaBit and other GaAs-chip manufacturers found that the high cost of their chips narrowed the market considerably.

GigaBit, with 1986 sales of less than $5 million, has overcome many of its earlier problems in manufacturing and hopes to nearly double its business this year. Most of this new business will come from supercomputer-maker Cray Research, which uses GaAs chips extensively in its new Cray 3 machine.

John Heightley

MICHAEL GARLAND/ONYX

Still, GigaBit is losing money. Its future looked uncertain earlier this year when its major investor, Analog Devices, decided not to join another round of financing. Cray, Digital Equipment Corp., and venture capitalists injected another $15 million into GigaBit last May. The company expects to become profitable before the end of this year and hopes to go public by early 1989.

Analysts say GigaBit will probably be taken over if it stumbles, continues to lose money, and delays going public. It may also attract buyers that simply want in-house GaAs-chip manufacturing capability. A likely acquirer will be a systems manufacturer, such as Cray, that already depends on GigaBit as a supplier.

"We certainly don't desire at this point to be acquired," says John Heightley, GigaBit's chairman and CEO. "It's an entrepreneurial operation and we plan to build a successful company. But anything's possible."

AT A GLANCE

Founded 1981
Major products: Gallium-arsenide chips
1986 revenue: Less than $5 million
1986 profit: Not available
1908 Oak Terrace Lane, Newbury Park, CA 91320
(805) 499–0610

technology, manufacturing capacity, and marketing capability. In each case, such partnerships are being used to fill dangerous holes in a chipmaker's business.

Motorola, for example, the number-two U.S. chipmaker, signed an agreement last November with Toshiba of Japan to jointly manufacture memories and microprocessors in a plant now under construction in Sendai, Japan. The pact gives Toshiba access to Motorola's popular 32-bit microprocessor technology; Motorola gets a share in a highly efficient manufacturing facility and a source for DRAMs. But the big attraction for Motorola was opening up Japan. The Toshiba alliance may prove the "magic formula" for effectively penetrating the Japanese market, says Chuck Thompson, Motorola's senior vice president and director of worldwide marketing.

LSI Logic also wanted to establish a Japanese manufacturing base and lower its manufacturing costs, but did not have $100 million to spend on a modern chipmaking plant. Kawasaki Steel of Japan wanted to get into the semiconductor business. In July 1985, the two companies agreed to build a state-of-the-art facility in Japan, of which Kawasaki Steel will own 45 percent.

Although partnering is certainly an important survival strategy for weaker U.S. chipmakers, it may not be a strategy for maintaining independence. "You've got to get big to play in the big leagues," says In-Stat's Beedle. For weaker players, he says, "partners are just a phase in the consolidation. You become a partner and eventually you lose your identity, either by being bought or by merging." ■

Michael R. Leibowitz is a business writer who specializes in the electronics industry.

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Smart Cards Get Smarter

A new breed of credit card will soon invade the U.S., creating a $3-billion market every five years

By G. Berton Latamore

A REVOLUTION is on its way to U.S. wallets. Sometime in the next few years, MasterCard International and Visa will replace their magnetic-strip cards with flat plastic rectangles containing computer chips.

The decision by MasterCard to test so-called "smart" cards this year means that the money foreign companies have spent to develop the technology may be about to pay off in the United States. Both MasterCard and Visa have close business ties with major French credit-card companies that have been using smart cards commercially for several years. One of them, Groupe Bull of Paris, has invested $50 million in the technology.

That's small change compared to the potential market. The eventual introduction of smart credit cards in the U.S. would require the installation of eight to ten million card readers. These machines would range from $600 free-standing units to devices costing $50 to $100 that plug into personal computers or point-of-sale terminals. The real market, however, is the cards themselves; if use becomes widespread, a billion cards costing about $3 each would be needed for the financial-services market alone. That translates into $3 billion in gross revenue for the makers every five years, as cards have to be replaced.

PHOTOGRAPHY BY STEVEN MARK NEEDHAM

LASER CARDS

HOW THEY WORK: Laser cards store information as tiny black dots burned into the surface by a laser in a special computer terminal. A less-powerful laser that works much like a compact disk player reads the card. Laser cards hold as many as four million characters, much more than chip-based cards.
PRIMARY USE: Medical records
OTHER USES: Portable storage of large amounts of data
WHO MAKES THEM: Drexler Technology; Optical Recording Corp., Toronto.
TRIALS: NASA (10-30 cards) for astronauts' medical records ■ Pesch & Co. (proposed, 1,000 cards) for medical records
LIKELY COMMERCIAL INTRODUCTION: Possibly within a year

Unlike current credit cards, which store information on a magnetic strip and are easy to read, alter, and forge, smart cards protect the information they carry with an electronic lock. Smart cards can also check each charge against a bank balance to avoid overcharged accounts and eliminate the time and cost of long-distance calls to authorize purchases.

MasterCard sees the smart card as an answer to theft and fraud, which is fast approaching $2.5 billion a year. But financial services provide only about half the potential market for new card technologies, says Richard Dunham, president of Micro Card Technologies in Dallas, a Groupe Bull subsidiary and one of two smart-card makers in the United States. Smart cards can also store medical and health-insurance information, phone numbers, appointments, or other records.

This versatility, when applied to the federal government, the health-care industry, data security for personal computers, and building-security systems, could create a bonanza of at least a billion more cards.

Although smart cards seem to have the edge in financial

services, different souped-up cards are competing for other parts of the market. At least three companies—New York-based SmartCard International (SCI), Intellicard of Colorado Springs, Colo., and Japan's Toshiba—are developing versions of a "unified" card that has its own keypad, screen, and battery.

SCI, which pioneered the unified card, is developing a reprogrammable version called the Ulticard with a 64,000-character memory—essentially a wallet-sized computer. Unlike the smart card and the conventional magnetic-strip card, Ulticard needs no terminal. However, SCI is covering its bets by making sample lots of standard smart cards and negotiating with several domestic electronics manufacturers to provide volume production of both smart cards and Ulticards when commercial development starts in North America. "Most people expect the basic smart card to be the general-purpose charge card," says Stephen Seidman, editor and publisher of the *Smart Card Monthly* newsletter.

SMART CARDS

HOW THEY WORK: The card contains a computer chip that provides processing power and an electronic memory that does not lose its data when the power is shut off. Most smart cards have a premanent memory of 8, 16, or 32 kilobytes; new versions use chips with reprogrammable memories.
PRIMARY USE: Credit cards
OTHER USES: Banking, medical records, building security
WHO MAKES THEM: In the U.S.: SmartCard International, Micro Card Technologies. In France: Groupe Bull, Flonic Schlumberger, Philips Data Systems.
TRIALS: Affiliated Health Care (500-1000 cards) for medical records ■ MasterCard (500-1000) for financial services ■ U.S. Department of Agriculture (2000+ cards) to track peanut sales ■ Royal Bank of Canada (500+ cards) for data access ■ Identix (100,000+ cards) for building security
LIKELY COMMERCIAL INTRODUCTION: Used in Canada and France now; by 1990 in the U.S.

Drexler Technology of Mountain View, Calif., champions a third variant—optical-memory cards that lack built-in computing power. The company's product, called the Drexon Laser Card, holds four million characters, as much as about 100 smart cards.

Optical-storage cards are best suited for disseminating large amounts of data. Company president Jerry Drexler, the card's developer, gives as an example field-repair manuals, which must be available at a moment's notice in thousands of locations. "If all technical manuals were published on cards it would be a 10-billion-card market," says Drexler.

However, Drexler Technology has been hamstrung by a lack of terminals. The company lost control of its destiny when it elected to license the development and manufacture of terminals to large Japanese electronics companies. Drexler has spent $35 million on the technology since 1981, but it lacks the resources to develop both the cards and terminals.

Two years ago, that problem caused Blue Cross/Blue Shield of Maryland to shelve a plan to put medical records on a Drexon card. However, the idea is being revived with the introduction of the first mass-produced Drexon terminals by Los Angeles-based Nippon Coinco, which also is hinting at plans for a battery-operated, hand-held terminal. London's Charing Cross Hospital also plans to use Drexon cards supplied by British Telecom to record ultrascan images and chart the course of pregnancies.

But Drexler is not alone with its laser card; recent entrants into the field include Japan's Dai Nippon Printing Co. and Toronto-based Optical Recording Corp. Nor does the optical card own the market for medical-record storage. Affiliated Health Care in Princeton, N.J., is testing a smart card instead, partly because the Drexon card carries too much information, according to Kate Fogel, Affiliated's vice president of marketing. "Doctors don't want to be liable for something they missed on page 699 of an 800-page report," she explains.

In Affiliated's test, done in the Princeton area in conjunction with Visa, the smart card stores a summary of an individual's medical record, including warnings about medications, allergies, immunizations, and chronic health conditions, plus names and phone numbers of the card-holder's physicians. If more information is available on Affiliated's database, the card works with a personal computer for quick access to medical records. Additional trial sites will be selected later this year. Eventually, Visa might offer the Affiliated services to all its members.

The ultimate in portable data-gathering may come from the unified card. Methodist Hospital and Baylor College of Medicine, both in Houston, are using SCI's Ulticard to monitor the diets of outpatients suffering from heart disease, diabetes, and obesity. In June, patients started carrying an Ulticard to record what they ate. This not only reminds them to stay on their diets, but also gives their doctors an accurate account of what the patients are eating, says Alan J. Herd, medical director of the Methodist Hospital's Institute for Preventive Medicine. Late this year, the medical institutions plan to start a field test involving about 200 patients who are not connected to Methodist Hospital or Baylor. One goal of this second program is to introduce the Ulticard to medical professionals outside the Houston area.

The Ulticard may find uses wherever people need to record numerical data easily in the field. Poll takers might find the card easier to use than a clipboard, and field reseachers of all kinds need a better way to record minute-to-minute observations. PA Technologies, a design and development firm in Princeton, N.J., is experimenting with adding a short-range radio transmitter to the card. The transmitter

sends information as soon as the user enters it, eliminating the need for a card reader.

Another potential application—building security—has already attracted commercial interest. Identix, of Palo Alto, Calif., is marketing a smart card that stores digitized fingerprints. To open a secure door in an industrial plant, for example, an employee slips the card into a reader built into the wall, taps in an identification number, and places a thumb on a sensor. If everything matches, the door opens. The optical card, with its huge memory, could prove more versatile as a security tool—one Drexon card could store a thumbprint, photo, and voice print.

The smart card has a strategic advantage over the other card types because it is the only one in mass use. Invented in France and backed by the French government, it has seen extensive use throughout that country as a bank and charge card, a telephone-debit card, and as a method of storing copies of students' records and schedules at universities. In the United States, MasterCard is just finishing field trials of smart cards in Columbia, Md., and West Palm Beach, Fla. The trials have proved that the cards survive being sat on—an insult not inflicted by French men, who typically carry their billfold in their jacket rather than in a rear pocket.

The unified card and the Drexon card still face technical hurdles. SCI's Ulticard prototypes use five chips, which make them too thick to fit in a wallet. The final one-chip version will be reinforced to protect the chip, screen, and other delicate components from seated assault. This card will come out next year, according to Lessin.

The Drexon card, too, faces the wallet test. Some experts wonder whether scratches and grime will obscure the data from the readout laser. Also, the Nippon Coinco terminals have yet to be proven in the field. Even if the hardware performs according to plan, there is still a software gap, says Stuart Crane, an optical-card specialist at the Battelle research institute in Columbus, Ohio. No software is available to read the information on the cards and translate it into English, says Crane, who estimates it will be at least two years before an easily installed terminal is developed.

The technical problems of the new cards are solvable; a bigger issue may be economics. Conventional magnetic-strip cards cost about $1 apiece. Smart cards cost $2 to $3 each, as will laser cards in volume production. Lessin expects his Ulticard to cost users $20 each. That, argues Dunham of Micro Card Technologies, is too high if the cards will have to be replaced every two years, as is the case with today magnetic-strip cards.

Lessin responds that holders of premium charge cards now pay much more than $20 a year for their magnetic-strip cards. He also asserts that the Ulticard will be made of much higher-quality materials than present-day charge cards, which are designed to wear out in two years because the issuing companies can control them only by replacement. Unified cards can be changed at any time simply by reprogramming them.

The real issue, says Seidman of *Smart Card Monthly*, is market control. If MasterCard starts distributing smart cards nationwide soon, the French technology will gain such a head start that it may be impossible for the others to catch up.

This is not an unlikely scenario. In March, MasterCard's board of directors authorized further testing of the technology. As a result, a group of executives from member banks is analyzing the potential impact of the chip card on credit losses, and MasterCard is involved in field tests in Germany, New Zealand, Mexico, Canada, and Japan. Executives from MasterCard and Visa are discussing working together to introduce the technology in North America. A joint plan would spread the cost of acquiring terminals—a major concern of the banking community.

According to industry experts, the main holdup may be the negotiations between MasterCard and Visa. Although MasterCard believes the smart card will earn back its cost in savings on fraud alone, Visa intends to convert to a new technology only if it provides new revenue-generating services. Still, if MasterCard starts mass distribution of smart cards in 1988, as predicted by test-cards supplier Micro Card Technologies, it will be tough for Visa—and the other large financial-services providers—to resist joining in. Once those cards and terminals are in the field, it will be hard to avoid the logic of using them whenever possible.

If that's the case, the smart-card pioneers could be even smarter than the cards they're selling. ■

UNIFIED CARDS

HOW THEY WORK: Like smart cards, unified cards contain a computer chip. But unified cards add battery power, a two-line display screen, and a keyboard, so users can enter and read information without a computer terminal.
PRIMARY USE: Financial transactions and records
OTHER USES: Portable data collection
WHO MAKES THEM: Smart Card International (under trade name Ulticard), Intellicard, Toshiba.
TRIALS: Houston's Methodist Hospital (400 cards) for medical records ■ Visa (100-200 cards) for financial services
LIKELY COMMERCIAL INTRODUCTION: Three to five years

G. Berton Latamore writes on technology topics for a number of national publications.

The Race After Genentech

A new generation of drugs that fight blood clots may help small biotech companies pass the industry's leader

By Helen Wheeler

THIS YEAR BROUGHT a one-two punch for Genentech, the San Francisco-based biotechnology company. First came the left hook: the Food and Drug Administration denied the company permission to market TPA, a drug that dissolves blood clots. Then came the right cross: a court rejected Genentech's broad-based British patent for TPA.

These rulings created a sensation in the biotechnology industry. Genentech is the biggest company in the field, and its version of TPA is further along in tests on humans than anyone else's. That meant the company was closer to opening up a market that some have figured as worth $500 million to $700 million, based on estimates that 270,000 people in the United States are candidates for the drug.

But after a bit of reflection, it seems Genentech is down but not out. Even though the FDA ruling postponed the company's TPA introduction by at least a few months, the blow was not fatal. Although Genentech has put a lid on public comment since the rulings, optimists at the company predict the product could come out as early as this fall.

However, the delay has given other companies several important strategic advantages. As a result of Genentech's FDA troubles, other companies know more about the kind of information the agency wants, and can perhaps plot their drug-testing programs more efficiently. Also, the patent loss, though it does not cover the United States, helps allay the fear that companies could be prohibited from making any variety of TPA that uses genetic engineering in its development.

Perhaps the most important factor is the most subtle one. Even if Genentech's product is the first TPA to reach the marketplace, industry analysts say, it could quickly be superseded by so-called "second-generation" TPA or other anti-clotting drugs being developed by competitors. "In terms of first-generation TPA, Genentech is the leader," says James McCamant, editor of the *Medical Technology Stock Letter*. "With second-generation products it becomes anybody's race, especially when you start talking about combining drugs and using new delivery systems."

The battle over TPA has expanded interest in biotechnology among the giant pharmaceutical houses. These companies are lining up to increase funding and marketing expertise to companies smaller than Genentech, enabling them to compete on a more equal footing.

Integrated Genetics is one example of the smaller companies that have benefited from Genentech's problems. The company, founded in 1981, is far smaller than Genentech. Integrated Genetics' 1986 revenues of $8.5 million came from research contracts and fees rather than product sales. However, BASF of West Germany and Toyobo/Daiichi of Japan are financing its research and testing. Also, Integrated Genetics is pursuing more than one version of TPA as well as two other anti-clotting proteins. Analysts say this aggressive approach gives Integrated Genetics an advantage. "It's not dependent on one product for success," says Margaret McGeorge, a biotech analyst for Branch Cabell, an investment research firm.

Like most other competitors, Integrated Genetics is pursuing a long-term strategy by working on a second-generation version that lasts longer in the body and requires less of the drug to dissolve the clot. This process involves altering TPA's genetic structure through protein engineering, and Integrated Genetics is considered a leader in producing the necessary proteins.

The company's research focuses heavily on this second-generation TPA, for which it has filed patent applications but which is still in the development stage. However, the company has not abandoned its hopes for a first-generation version, even though it lags behind at least two other companies in its schedule for testing such a version (Integrated Genetics plans clinical trials in the United States this fall).

BILL O'CONNELL

Robert J. Carpenter, Integrated Genetics chairman and president, hopes his company's second-generation TPA may eventually displace Genentech's market leadership.

Like Genentech's TPA, Integrated Genetics' first-generation drug starts with TPA as it occurs in nature. However, Integrated Genetics' first-generation process uses a different type of cell than that of Genentech's version, according to David Paisley, a chemistry professor and president of a biotech consulting firm. Paisley says this difference should protect the company from any Genentech patent challenge.

Patent protection is critical, experts say, because as more and more biotechnology products finally reach the marketplace, courts will increasingly be forced to decide to what extent patents cover emerging processes as well as products. No patent has yet been granted for TPA in the United States.

The patent question is particularly important in the case of Genetics Institute. Though far smaller than Genentech, the company has roughly four times the market capitalization of Integrated Genetics, and it has been running clinical trials on its first-generation TPA longer than anyone except Genentech. More important, Wellcome PLC of London, the victor against Genentech in the British patent ruling, licensed its first-generation TPA technology from Genetics Institute, which will receive royalties from anything Wellcome sells.

However, the British court decision was not an unqualified benefit to Genetics Institute. The company was just as damaged as other companies when the ruling prompted a drop in TPA-connected stocks—though not, of course, as

much as Genentech. Also, appeals of the decision could delay final resolution of the case for as much as two years. If Wellcome goes to market before the suit is resolved, and if Genentech wins, Wellcome could be forced to pay damages for patent violation.

But Stuart Weisbrod of Prudential-Bache Securities does not think Genetics Institute will reap substantial revenues from its first-generation TPA. Under the arrangement with Wellcome, the company will receive royalties from sales of the drug but no revenue from its manufacture, which Wellcome will do itself. Also, Wellcome is 12 to 18 months away from applying for FDA approval in the United States.

Like Integrated Genetics, Genetics Institute is banking on second-generation TPA, and hopes to begin human testing in the United States next year, according to Garen Bohlin, senior vice president of finance and administration. However, Genetics Institute has not lined up partners for its second-generation research. The company reports good results in animal tests of the product, and some analysts rate it as one of Genentech's stiffest competitors.

Further behind both companies is Bio-Response, which like others had hoped that a Genentech victory could eventually force a number of competitors with similar technologies out of the running. According to the *Biotech Investor* newsletter produced by Casdin Associates, a research firm that tracks the biotech market, Bio-Response is even smaller than Integrated Genetics or Genetics Institute. Because Bio-Response does not use recombinant-DNA techniques to produce its TPA as Genentech and the other competitors do, it probably will avoid any patent battles.

"We are cheering for Genentech, because if their patent position is ultimately maintained, it will eliminate a large number of players. It's as uncertain as it was before," says Alfred G. Daniel, president of Bio-Response, who believes that U.S. courts ultimately will see things much differently than the British court did.

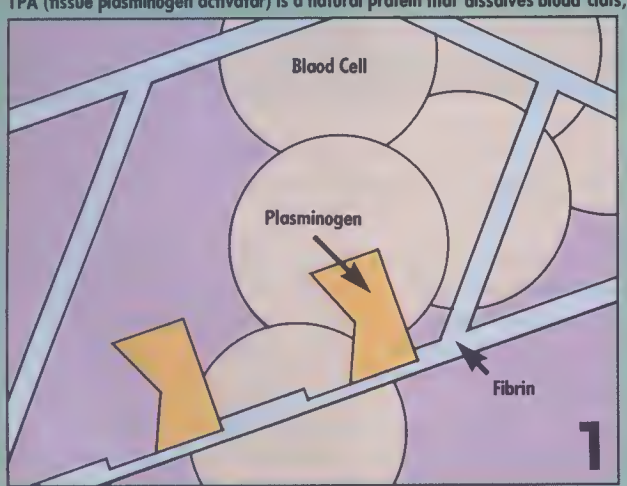
However, both Linda Miller, a biotechnology analyst for Paine Webber, and McCamant of the *Medical Technology Stock Letter* rate Bio-Response's chances of catching TPA's gold ring as far slimmer than either Genetics Institute's or Integrated Genetics'; Bio-Response's time frame for testing is even further behind that of those companies. Bio-Response also lacks the deep pockets of a large corporate partner. The company is involved in discussions with potential partners worldwide but, according to Daniel, "No one has made us an offer that we cannot refuse." Bio-Response also wants to wait until it gets results from its first human trials before beginning serious negotiations.

Another TPA-connected company, Damon Biotech, has a patent not on a TPA product but on a process that can be used to make first-generation TPA. The company calls its process the Encapcel system, but is still two to three years away from getting any product to market. By that time, says Prudential-Bache's Weisbrod, second-generation products will be hitting the market. However, Damon Biotech is hoping the TPA market will be large enough to accommodate even a late entry. Its partner is the pharmaceuticals giant SmithKline Beckman; with $3.7 billion in sales last year and an anti-hypertension drug already on the cardiovascular market, SmithKline Beckman obviously has the financial assets and marketing muscle Damon Biotech needs.

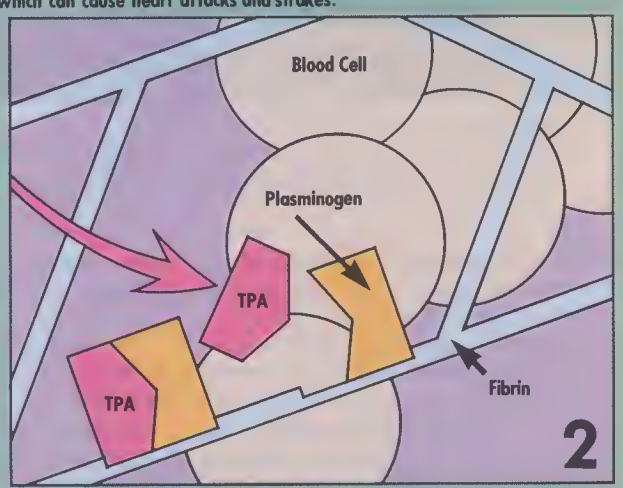
SmithKline first signed with Biogen N.V., whose version of TPA is much like Genentech's. Biogen is behind Wellcome in its clinical trials. McCamant describes Biogen as a "major disappointment" because it has expended more than twice as much on research and development as it has collected in revenues, which dropped from $21.5 million in 1985 to $10.1 million last year. Analysts say Biogen is putting TPA on the back burner. Not only has SmithKline Beckman begun putting money into other companies, but Biogen's production method is the same as Genentech's, making it vulnerable to a patent challenge even if Genentech gets a patent

How TPA Works

TPA (tissue plasminogen activator) is a natural protein that dissolves blood clots, which can cause heart attacks and strokes.



Blood cells are held back by a netlike substance called fibrin. Attached to the fibrin is plasminogen, a protein found in the blood.



When injected into the bloodstream, TPA binds to the fibrin at the open site next to the plasminogen.

KAREN KARLSSON

that covers a very specific process.

SmithKline's latest venture involves British Biotechnology Ltd. of Great Britain. This company will genetically engineer TPA peptides (linked amino acids, which are the building blocks of proteins such as TPA) and SmithKline will do research for possible marketing. However, clinical tests for this product are two to four years away.

"Our collaborations maximize our chance to emerge in the top tier of successful companies," says SmithKline Beckman vice president Barry Berkowitz.

SmithKline's involvement is typical of the interest increasingly being shown in developing biotechnology products. Many larger companies are content to use their massive financial resources to buy expertise from the smaller biotech operations, which often are still in a research-and-development phase rather than generating revenue.

As the biotechnology industry begins to move from research to production, more large companies are entering the fray.

■

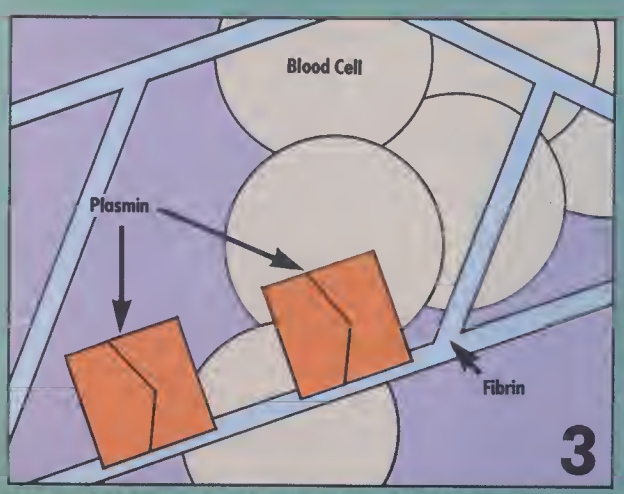
However, as the fledgling biotechnology industry begins to establish markets by moving from research to production, more large companies are entering the fray. The TPA battle, for example, includes the giant pharmaceutical house Eli Lilly, which has chosen to do its own research. It is not disclosing its plans, but the company is known to be working on a second-generation product, according to David Webber, editor of *Biotech Investor*. Lilly already has entered the cardiovascular market through such medical instruments as catheters.

G. D. Searle, a division of Monsanto, plans to market a second-generation TPA being developed by Monsanto in conjunction with a privately held company in St. Louis named Invitron. It is perhaps a sign of the new interest in TPA that Monsanto and Invitron were working on the drug before Monsanto bought Searle.

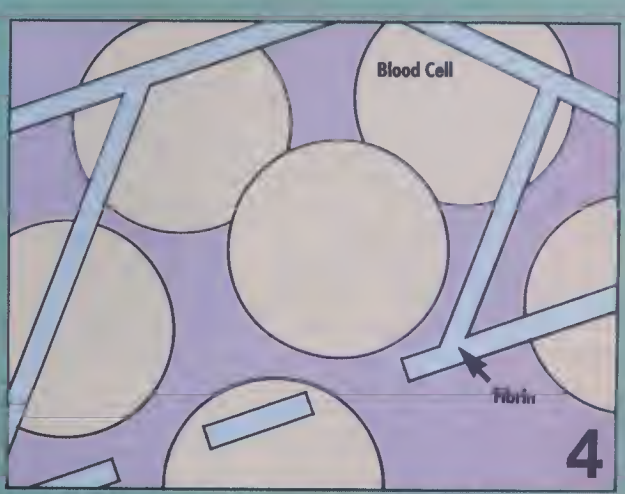
Still other companies have chosen to produce drugs that can ride the coattails of whoever comes out on top in the TPA battle. For example, Collaborative Research has teamed with Sandoz, a Swiss company that sells chemical, agricultural, and pharmaceutical products. The two companies plan to manufacture and market an anti-clotting drug called prourokinase that may work with TPA—as TPA dissolves a blood clot, prourokinase speeds the process and seems to prevent the clot from forming again. As a clot-dissolving drug, prourokinase could compete with TPA. However, even if TPA dominates the anti-clotting market, prourokinase's special properties may still provide profits for Sandoz, which holds the marketing rights worldwide. "It's hard to say anything definitive [about prourokinase] until there is more data and we can compare it with other drugs," says Thomas Oesterling, president and chief operating officer of Collaborative Research. "But we are in much better shape than TPA from this standpoint." Both Sandoz and Genentech are seeking patents for using the drugs in combination. Consultant Paisley speculates that each company will offer slightly different formulations to avoid patent infringement.

A similar strategy is being pursued by Boston-based Genzyme, whose market capitalization is slightly lower than Damon Biotech's. Genzyme has developed a method by which TPA makers can alter the sugar molecules that attach to TPA, thereby making a TPA product less vulnerable to patent challenge. The company has signed a research agreement with Genentech, but Genzyme says this agreement does not involve TPA.

Genzyme's ability to stay in the market seems fairly strong. The company is



TPA turns the plasminogen into plasmin, an enzyme that dissolves the surrounding fibrin.



As the fibrin dissolves, blood cells are released and the blood flows more freely.

THE TPA CONTENDERS

COMPANY	1986 REVENUES	1987 MARKET VALUE*	COLLABORATORS	PRODUCT	ESTIMATED TIME TO U.S. MARKET
Biogen N.V. 14 Combridge Center Combridge, MA 02142 (617) 864-8900	$10.1 million	$24.1 million	SmithKline Beckman, Fujisawa	TPA**	Two years
Bio-Response 1978 W. Winton Ave. Hayward, CA 94545 (415) 786-9744	$2.1 million	$38.3 million	Retroperfusion Systems	TPA**	Two years
Collaborative Research 2 Oak Park Bedford, MA 01730 (617) 275-0004	$11.6 million	$80.36 million	Sandoz Pharmoceuticals	Prourokinase	Not available
Centocor 244 Great Valley Pkwy. Molvern, PA 19355 (215) 296-4488	$38.8 million	$491.2 million	None	Anti-clotting mono-clonal antibody	Four to five years
Domon Biotech 119 Fourth Ave. Needham Heights, MA 02194 (617) 449-6002	$3.8 million	$148 million	SmithKline Beckman, Yomonouchi	TPA**	Two to three years
Eli Lilly Lilly Corporate Center Indionapolis, IN 46285 (317) 276-2000	$558.2 million	$12.8 billion	None	TPA**	Not available
Genentech 460 Point San Bruno Blvd. San Francisco, CA 94080 (415) 266-1000	$134 million	$3.25 billion	Boehringer Ingelheim, Kyowa Hhkka Kogyo, Mitsubishi	TPA**	By January 1988
Genetics Institute 87 Cambridge Park Dr. Cambridge, MA 02140 (617) 876-1170	$24.3 million	$464 million	Wellcome PLC	TPA**	Not available
Integrated Genetics 31 New York Ave. Framingham, MA 01701 (617) 875-1336	$10.1 million	$93.4 million	BASF, Toyobo/Daiichi	TPA**	Two to three years
Monsanto (Searle) 800 N. Lindbergh Blvd. St. Louis, MO 63167 (314) 694-1000	$7.5 billion	$6.4 billion	Invitron	TPA***	Not available

*Outstanding shares times stock price as of 6/19/87
**For first-generation TPA; second generation still in research stage for all companies
***Working on second-generation TPA only

HIGH TECHNOLOGY BUSINESS RESEARCH

already marketing several diagnostic tests that generated about $4 million in revenues last year. Genzyme's entrance into the TPA market is hampered, however, because it is still at the development stage. As McCamant points out, the diversity of approaches puts additional pressure on Genentech, which has staked its TPA chances on its first-generation product.

Other companies are pursuing anti-clotting solutions that have nothing to do with TPA. For example, Centocor, which has the fourth largest market capitalization among 102 biotech companies analyzed by *Biotech Investor*, has applied for a patent on a monoclonal antibody that can prevent blood clots from forming and may also help keep clots from recurring. Centocor estimates that this antibody will appeal to the same market as TPA.

Foreign companies also are a factor in the race. Streptokinase, which received FDA approval for treatment of heart-attack victims at the same hearing at which Genentech received its setback, is produced by Hoechst-Roussel of West Germany and Kabivitrum of Sweden. A modified version of streptokinase, produced by England's Beecham and dubbed Eminase, is about a year away from market. Because it is expected to be priced at about $200–$250 per dose compared to TPA's estimated $1,500–$2,000, it could significantly affect pricing of any TPA product even though it is considered less effective in breaking up clots and Beecham's U.S. marketing would probably be weaker than that of American companies.

"When you have a large number of similar products, the competition becomes much more a game of marketing," says *Biotech Investor*'s Webber. "The suddenly manifested vulnerability of Genentech's TPA in particular, and overall corporate strategy in general, has revitalized the firm's competitors. The psychological impact of Genentech's setback will have tangible consequences." ■

Helen Wheeler is an associate editor of HIGH TECHNOLOGY BUSINESS.

Military Software's New Market

The Defense Department's tougher stance nurtures the Ada support industry

BY DAVID FREEDMAN

WHEN THE Department of Defense issued new regulations governing software earlier this year, it was like a mother getting tough with children who had pushed her too far. For three years, the department had been trying to cut costs by standardizing its computer software, specifying a programming language called Ada for all software in "mission critical" systems—basically, anything that flies or blows up. But defense contractors had avoided the conversion by claiming it would ensure budget overruns. Waivers to the Ada mandate became the rule rather than the exception.

In response, early this year the department issued a more stringent mandate that makes it harder for contractors to avoid Ada. "The percentage of contractors getting waivers will fall from 70 percent to 30 percent," says John Pates of Massachusetts Computer Associates, a company in Wakefield, Mass., that writes Ada programs.

Now some of the largest defense projects in development are solidly committed to Ada, such as the Air Force's Advanced Tactical Fighter—a $40-billion program that's expected to be more than 80 percent software development. That's a welcome change for companies that invested early in Ada. "A lot of companies that put money into Ada product development have yet to see that investment pay off," says Charles Bickley, Ada product manager of Softech, a software company in Waltham, Mass. The Ada crackdown is expected to create massive new sources of income for suppliers of Ada programming equipment and expertise to such defense contractors as TRW, Boeing, and Martin Marietta.

The payout to such contractors for defense software written in Ada will grow from about $700 million this year to a whopping $16 billion in 1990, according to International Resource Development (IRD), a management consulting company that follows the Ada market. Defense contractors will drastically increase their spending on the products they need to write Ada programs to get those contracts. What now represents $130 million in revenues for the fledgling support companies may reach $500 million by 1990, according to IRD.

Not an acronym, the Ada programming language is named for Augusta Ada, Countess of Lovelace, a follower of computer pioneer Charles Babbage.

BETTMAN ARCHIVE

Heretofore, the market for Ada support products has been dominated by small, independent companies, often privately owned. These companies create the software (and sometimes the hardware) that defense companies need to write Ada programs, including systems that translate

between Ada and computer hardware. They create systems on which programmers write Ada code. They may also contract with defense companies to do Ada programming, or serve as consultants to defense companies converting to Ada.

But as the language gains momentum, such large, mainstream computer companies as Data General and Digital Equipment Corp. are looking to play a more dominant role in the market for Ada programming supports. Their appearance could threaten some of the smaller contenders that have made Ada their mainstay. To insulate themselves from the competitive power of the giants, many smaller companies are settling into niches that are too specialized for the full-system computer companies. So far the strategy has worked, but that may only be because the market is expanding rapidly enough to accommodate the proliferation of smaller companies. In the future, IRD president Kenneth Bosomworth anticipates consolidation: "It won't be a question of large companies moving in and dominating, as much as acquiring the specialized companies."

The likely buyers, of course, include the big guns that sell systems and have already staked a claim in the Ada market. The first one to hit on Ada is Digital Equipment Corp. (DEC), which has already captured the lion's share of the market for compilers for its VAX computers. Compilers are basic software packages that a computer uses to translate Ada. "We're as busy as we could possibly be," boasts DEC's Ada product manager David Quigley. Other systems companies offering Ada support products include Honeywell, Data General, and Concurrent Computer. "It's an opportunity for both increased hardware and software profits," says Concurrent's software products manager Dennis Tinley.

For now, many systems suppliers seem content to work cooperatively with the independent companies; instead of competing, in some cases the computer giants are expanding the customer base of the smaller Ada suppliers. DEC, for example, is jointly developing Ada-support software with Systems Designers of Woburn, Mass., and AT&T has worked with Intermetrics. Other large computer companies have so far opted to simply resell compilers purchased from smaller companies, as Harris has done with Verdix.

IBM, which often sets the course of the computer industry, has moved its Federal Systems Division aggressively into competition with defense contrac-

ADA HITS THE PRIVATE SECTOR

THE GROWING use of the Ada programming language in military computers is less a tribute to its appeal than to the diligence of the Department of Defense, which now demands the language. But interest in Ada is building in nondefense markets as well, partly because business managers are becoming sold on Ada's ability to cut costs and boost software quality.

With Ada, programmers must carefully plan their programs. Although this increases the time spent on design by about 50 percent, it also cuts the number of errors that creep into a program by 75 percent, resulting in a crucial cost savings.

Because finished Ada programs are better organized and more clearly mapped out, they are easier to modify. Also, Ada programs use interchangeable modules that let programmers create a library of building blocks for writing subsequent programs. For these reasons, Ada is expected to cut 60 percent of the costs of building and reworking a program over its lifetime.

As such advantages attract commercial programmers, companies that supply Ada support will be looking at a civilian market that could grow to $150 million in annual sales, estimates analyst Kenneth Bosomworth of International Resource Development, a company that offers management consulting.

Ada's first major civilian inroads came through government agencies and commercial-aviation businesses with links to the defense industry. For instance, Boeing relies heavily on Ada for its 7J7 aircraft development. NASA's space station and the Federal Aviation Administration's next-generation air-traffic-control system are also committed to Ada.

Recently, large software suppliers—especially those seeking an edge in government sales—have begun using Ada in both their military and commercial programs. IBM has quietly taken a lead in this regard, motivated by Ada's programming advantages as well as by the company's Federal Systems Division's hunger for military contracts. "They won't say much about it to the outside world, but they're embracing Ada in a big way," says Captain Glen Hughes, a Pentagon staffer who reviews Ada software projects for the Army. Because the military is pushing contractors to supply off-the-shelf rather than custom programs, he says, IBM and other software sellers plan to fulfill contracts with Ada software that can also be marketed to businesses.

Computer Corporation of America (CCA) of Cambridge, Mass., and CRI of Santa Clara, Calif., have both enlisted Ada to develop database-management systems. CCA sells mainly to government markets, but CRI's Relate/DB is probably the first major commercial software product written in Ada. The language's tight structure helped keep the program to a fifth the size of a typical competitive offering, says CRI vice president of marketing and sales Paul Fuller, and Ada's versatility enabled CRI to create versions of the product for seven different computers in one year instead of the several years that are normally consumed by such a project.

The big question is whether Ada will catch on among information-systems departments, which write software for their own business needs. In this market, the biggest hurdle is the entrenchment of Cobol in business programming. Experts insist Ada is better, pointing out that it offers businesses the same benefits as it does the defense industry. "A large bank system has the same kinds of problems as a battlefield-management system," says Thomas Winfield, software engineering technology manager in the Ground Systems Group of Hughes Aircraft. —*D.F.*

tors for Ada military contracts. To do so, IBM has at times developed Ada programming equipment to fulfill its defense contracts if nothing appropriate was available from independent companies. But so far, IBM has shown no intentions of selling these Ada-support products to outsiders.

Some smaller independent companies that jumped into Ada support early have already established strong positions, from which they will be difficult to displace. For example, Rational hopes to grab a $100-million piece of the market by 1992, according to company vice-president Robert Bond. Offering both hardware and software to defense companies, Rational is the clear leader in the high end of the market for Ada programming systems. Its products are used in about 40 major projects, and Bond expects that number to double a year from now.

Rational, like most companies that specialize in Ada-related markets, is privately held and does not release financial information. But Bond predicts the company, founded in 1980, will become profitable later this year. To help reach this milestone, Rational plans to pursue two high-growth opportunities: international sales and the market for lower-cost Ada programming systems. "Our goal is to keep pushing the entry-level price down, to offer an attractive solution for developers of smaller Ada projects," says Bond.

Of the companies that offer software alone, one of the more successful is Softech. Publicly held, Softech derives about half of its $45 million in annual revenue from software that assists Ada programmers. Ada product manager Bickley asserts that, under the Defense Department's tougher mandate, the market for Softech's products could double every year for the next several years.

A number of independent software companies are seeking profitable niches by selling Ada programming equipment for use on a variety of computers. One of the leading suppliers of compilers is Verdix; the company supplies about one-third of the approximately 75 computer compilers currently offered under other companies' names, according to Stephen Ziegler, the company's vice president of Ada products. This widespread acceptance has been a factor in helping Verdix achieve profitability in the last two quarters.

GEORGE STEINMETZ

Robert Bond is maneuvering Rational toward a goal of $100 million in annual sales of Ada hardware and software by 1992.

Other suppliers are establishing niches by offering software that runs on only one type of computer. Intermetrics, for example, has had little competition providing units for IBM mainframes, which are specified in some contracts.

At the opposite end of the computer spectrum, a few companies aim to establish themselves with software that lets programmers write Ada on personal computers. Meridian Software Systems expects its bargain-basement price of $795 to open up a new market of programmers who want a low-cost way to experiment with Ada. Alsys, a software company, sells Ada programming software along with the necessary hardware to increase the memory of a personal computer.

Some smaller companies such as Pittsburgh's Lexeme are profiting from the push to Ada by offering complex, highly specialized systems that automatically write parts of an Ada program. Philadelphia-based Computer Command & Control sells a system that takes information about a program's design and churns out a nearly finished program. Vice president and general manager Evan Lock says two companies have already bought the $150,000 system, and he expects three more customers by the end of the year. A less costly route comes from EVB Software Engineering of Frederick, Md. Its $27,000 library of Ada program modules lets programmers select prewritten chunks of Ada code to fill in parts of their programs.

A number of companies are profiting from the growing market for Ada-related services. Other computer languages used by the military permit programmers to write twisted "spaghetti code" that is expensive and sometimes impossible to repair and modify, which adds to the cost of computer systems after they are installed.

Ada's rigorous structure forces programmers to write computer code that is more logically organized, but it

SETH RESNICK

David Quigley keeps Digital Equipment on top of the Ada pack by supplying specialized software for the company's VAX computers.

also makes the language hard to learn and programmers must be trained to take advantage of its subtleties. Companies that use Ada must be prepared to either bear the cost of training a corps of programmers or use outside help to do what can't be handled in house.

Although long-term demand for consulting, training, and custom-programming services may decline as programmers get used to the new language, the market at the moment holds many opportunities. Addamax of Tyson's Corner, Va., and Massachusetts Computer Associates, for example, specialize in writing Ada programs for defense companies, and Reifer Consultants of Torrance, Calif., provides cost/benefit analyses of Ada projects and other consulting services. In addition, many Ada-product suppliers supplement their earnings with custom services. For example, Intermetrics and Alsys do programming work for defense contractors, and EVB Software Engineering provides training and programming support services.

Even if large companies come to dominate the Ada market, there is no shortage of niches for small, independent companies. Indeed, defense contractors complain that they often must create their own programming aids for specialized computer systems. "Vendors are concentrating on the most popular computer systems right now," sighs Frank Belz, manager of the Ada Office of TRW's Defense Systems Group in Redondo Beach, Calif. "We have to try to convince them that it's in their interest to develop tools for other systems."

Thus it seems that, in the near-term at least, Ada opportunities will abound for the companies energetic enough to ferret out a niche. But in any business, success breeds competition; small companies that do well will attract covetous gazes from larger contenders. "I suspect a lot of smaller companies will be absorbed," says Softech's Bickley. ■

David Freedman is a senior editor of Infosystems, *a monthly magazine on information-systems management.*

THE ADA TOP 10

COMPANY	PRIMARY BUSINESS	MAIN ADA PRODUCTS
Digital Equipment Corp. 110 Spitbrook Rd. Nashua, NH 03062 (603) 881–2343	General-purpose computer systems	Compilers and related tools for DEC computers
Data General 4400 Computer Dr. Westbara, MA 01580 (617) 366–8911	General-purpose computer systems	Compilers and related tools for Data General computers
Rational 1501 Salada Dr. Mountain View, CA 94043 (415) 940–4700	Ada support hardware and software systems	Specialized computers and programming
Verdix 14130 A Sullyfield Circle Chantilly, VA 22021 (703) 378–7600	Ada support software	Compilers for a variety of computers
Softech 460 Totten Pond Rd. Waltham, MA 02154 (617) 890–6900	Ada support software and contractual program development	Compilers and related software products for a variety of computers
Intermetrics 733 Concord Ave. Cambridge, MA 02138 (617) 661–1840	Ada support software and contractual program development	Compilers for IBM computers
Alsys 1432 Main St. Waltham, MA 02154 (617) 890–0030	Ada support software	Compilers for personal computers
Meridian Software Systems 23141 Verduga Dr., Suite 105 Laguna Hills, CA 92653 (714) 380–9800	Ada support software	Compilers for personal computers
Concurrent Computer 15 Main St. Holmdel, NJ 07733 (201) 946–8883	Financial and military/aerospace computers	Compilers and related software for Concurrent computers
IBM, Federal Systems Div. 6600 Rockledge Dr. Bethesda, MD 20817 (301) 493–8100	General-purpose computer systems	Developing Ada software for IBM computers (no commercial products announced)

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

The garden slugs in a microelectronics lab at AT&T Bell Laboratories are very fussy eaters. They won't go near their favorite foods if they smell a whiff of garlic. Garlic? Garden slugs? What could that possibly have to do with making computers smarter? More than you'd ever imagine...

Slug as savant: "Nature has shown us there are powerful computer designs very different from conventional machines."

The common garden slug loves the enticing odors of carrot, tomato and mushroom. But it hates garlic. When scientists at AT&T Bell Laboratories "spike" these favorite foods with garlic, what happens? The slug learns. It alters its memory of the foods it once loved and avoids or rejects them.

Insights gained from studying simple central nervous systems like the slug's point to a dramatically new approach to computing. An approach that promises to make computers faster, smarter and easier for people to use.

Why study slugs? Though the slug is no Einstein, its brain's limited ability to learn—to associate new information with existing memories—makes today's most powerful computers seem primitive.

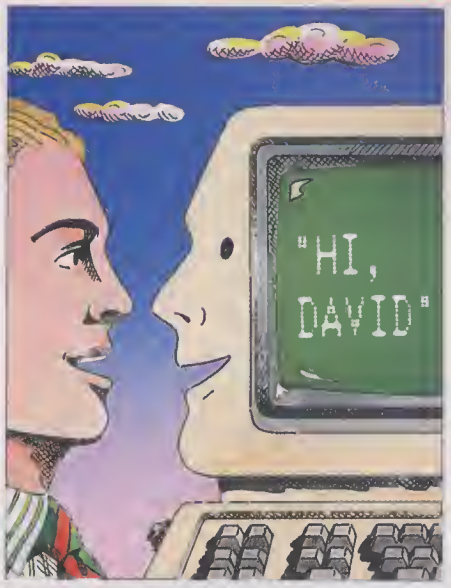
And the slug, with its neural networks comprised of a mere 500,000 nerve cells or neurons, is much less complicated to work with than people or other animals.

Microchips that mimic the brain

On functioning computer chips, microelectronics researchers have built prototype electronic neural networks.

Like biological networks of brain nerve cells, these electronic circuits use associative memory to relate incoming information to memories already stored. So they can cope with information filled with errors or ambiguity. And they can deal with "messy" information, collecting scattered facts to recognize and remember from incomplete details, much as the brain does.

One test chip, containing 54



In the future, people and their computers will have a much friendlier working relationship.

"neurons" in such a "neural network," can recall memories from imperfect data within a few millionths of a second—selecting "James Lynn" from among several stored names as the correct response to the input "Jim."

Getting up to speed

By studying simple central nervous systems like the slug's, scientists at Bell Labs are also gaining valuable insights into another brain function, parallel processing. It offers an answer to a physical limitation of today's computers—speed.

Step-by-step computing can only process information one piece at a time. Parallel processing, the ability to perform several functions simultaneously, speeds things up. And the more things done together, the faster the whole job gets done.

"Thinking" computers

Where is this research into associative memory and parallel processing leading? To "thinking" computers that make good judgments as well as good calculations. Computers that can perceive and learn in an imperfect world, much as people do.

In the future, working with computers will be more like working with people. The machines will understand and respond to human speech—even recognize the person addressing them.

Taking the longer view

Research scientists at AT&T Bell Laboratories are expected to take the longer view. To look beyond the impact of technology on the next quarter or the next year, into the next century.

It is this perspective that has produced seven Nobel Prize winners for Bell Labs. Some 21,000 patents, an average of more than one a day. And a legacy of achievement, from the transistor and the laser to lightwave communications and the digital computer.

This longer view ensures that the technology built into all AT&T products can evolve and adapt to the changing needs of the real world. Making information easier to obtain and use for everyone.

Today's computers can only process neatly-stored information. A little human ability to deal with messiness might actually make them a whole lot smarter.

AT&T
The right choice.

TRW Chairman Ruben Mettler

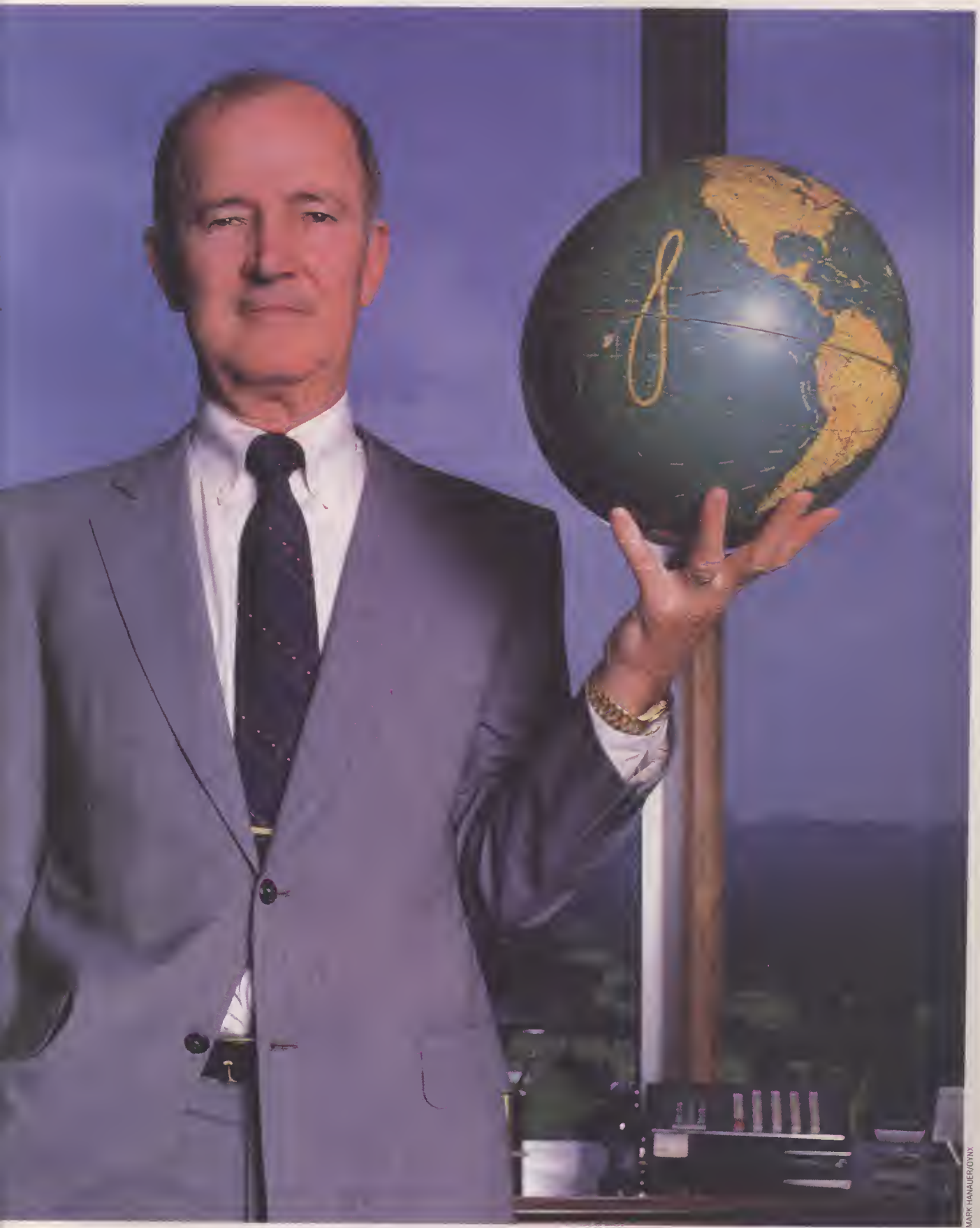
ON STAYING COMPETITIVE

IN THE RAPIDLY changing business of technology, executives rarely hold tenure as long as Ruben F. Mettler, who joined TRW in 1955 and has been chairman and chief executive officer since December 1977. During his years at TRW, he has been technical director of the Atlas, Thor, Titan, and Minuteman rocket and missile programs, and he headed development of a number of early scientific satellites, including Pioneer 1.

Mettler's achievements also extend to the business side. From 1978 to 1984, TRW's earnings rose more than 50 percent, to $264 million. In 1985, Mettler oversaw a massive restructuring in which the company shed $800 million worth of nonstrategic businesses, including aircraft components, industrial tools, and bearings, thereby narrowing its focus to more technologically intensive markets.

The revamped TRW sells advanced space and defense systems to the government. TRW's information services provide businesses with credit information and real-estate data. In addition, the company supplies automakers around the world with such advanced systems as electronically controlled power steering. With 1986 sales of $6 billion, the Cleveland-based company is ranked 58th in the *Fortune* 500.

With the dust still settling from the restructuring, HIGH TECHNOLOGY BUSINESS assistant managing editor Jeff Zygmont talked to the 63-year-old Mettler about competitiveness, discussing how established companies such as TRW can stay young in fast-moving businesses.



MARK HANAUER/OYNX

■ *HT Business: What's the biggest challenge to remaining competitive in high technology?*
Mettler: The time it takes to go from invention to a special application to a general-purpose, massive application is clearly a highly competitive race for any company. Being there first—either with higher quality, lower cost, better performance, or a brand-new product—is especially important as more companies enter international competition. Much of the science and basic technology developed in the United States comes back from Japan in products.

■ *HT Business: So companies that learn first or fastest to apply new technologies on a broad scale will have a significant advantage?*
Mettler: Exactly. Take ceramics. We can make one copy of a ceramic automobile component that will knock your eyes out. But we have a major joint venture focused mainly on reducing the cost and increasing the efficiency of the production process. Superconducting is the same way. One reason its development is going so fast is that we already know what it can do. The companies that have been working on technologies for a long time have only half the problem to solve—finding a way to make it cheaper and smaller.

■ *HT Business: Do you spend more on basic research, or on finding ways to mass-produce new products?*
Mettler: In the main, the amount of money spent on processing will be much bigger. For invention, a tiny handful of people on a campus with relatively small amounts of money can advance far, whereas TRW is investing $20 million for processing ceramics in our joint venture. The big money in the end will be in processing.

■ *HT Business: How does a company keep from falling behind in competitive markets?*
Mettler: At TRW, we elected to narrow our product range after a very elaborate and careful examination of our strengths, our competitive posture, and our strategic potential over a long period of time. Our basic strategy was to focus our products so we could put more of our research-and-development dollars, our management attention, and our best people over a narrower range of products. We don't want to spread ourselves so thin that we can't be best or near best in our markets.

We moved toward system technology. We're still the largest manufacturer in the world of automotive valves, or suspension links, or a lot of other pieces. But we're aggregating these pieces into larger, automated systems. We have thousands of people working full-time on software. Over 25 percent of our sales are in information-based technology businesses. That takes more technology; therefore you have to compete across a narrower range.

■ *HT Business: The factors that affect spending in the commercial markets are very different from those that affect the government/defense markets. Which do you find the most competitive?*
Mettler: In many ways, the government market is more competitive by a wide range. That's not the conventional wisdom. But let's take, for example, the advanced-technology fighter. There is only going to be one in the Air Force and one in the Navy from now to the end of the century. If you're in that business, you've got to win this one or you're out.

"In many ways, the government market is more competitive by a wide range. That's not the conventional wisdom."

■

It [the government market] is often regarded as not competitive by people who don't understand it. But the competitive aspect is to win the contract up front. It's a Russian-roulette type of competition. There aren't very many contracts, the stakes are large, and the initial research investment is enormous. That results in the teaming of companies—the stakes are so great that the companies cooperate.

Another form of competition is the ordinary commercial businesses. There are more competing companies, but they're dealing with many customers. You don't win or lose everything at one roll of the dice. Although it's very important to be out in front with technology if you're one of the leaders, it is possible to survive in commercial businesses even if your market share is 15 percent and someone else has 30 percent.

In commercial markets, it's particularly important to apply updated technology in a product. Technology's effect on quality is a clear and very critical advantage in any product. It can reduce costs and can certainly help after-sales service. It's important to think of technology very broadly, because there is a tendency for people to think of technology as product development and stop there.

■ *HT Business: So in commercial markets, technology is not just what you sell, but also how you produce it and support it?*
Mettler: Precisely.

■ *HT Business: How much do technology brokers like TRW rely on internal research and development for advances that will keep them competitive into the next century?*
Mettler: Even though we have a large research-and-development budget, we have an expression in our company: "Three-quarters of all the new technology that we're going to need in the next decade is now being developed or invented by someone else." I think that's true for any major company. It would be very dangerous for a company that depends on advanced technology to either assume they'll get everything they need from the outside, or to assume they're doing enough inside. We have a special organization that focuses on external ad-

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Mettler: There are many examples where technology is misapplied—the landscape is littered with companies that were too soon or too late with their products. We have an expression: "Technology push is a lot harder than market pull." In a fundamental sense, success requires knowing what the customer needs and wants. A beautiful example of that—which I hope we have timed correctly—is our gamble that automobile safety is going to become market driven. Safety technology in Mercedes, BMWs, Porsches, and other cars coming in from Europe is *way* ahead. That has not gone unnoticed by

■ *HT Business: Overall, how important is technology to modern corporate survival?*

Mettler: There is a hierarchy of technology requirements that depend on what kind of business you're in. Some can't be served without the absolute highest technology available. But you really don't need the absolute best technology in every business; this jacket I'm wearing doesn't have to be made of the stuff the astronauts wear. We've cast our lot with high technology. I'm not suggesting everybody do that. ■

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vances in the technology world. We also have special programs with universities—Cal Tech, Purdue, Stanford—with five-year commitments to support their research programs.

■ *HT Business: Where does the small, entrepreneurial company fit into your thinking on future technology?*
Mettler: We are constantly investing in small technology companies, many in the software and data-management business. For example, we have 15-percent equity in a small company started by a couple of professors from the University of California. Their work ties directly to some of the major things that our information-systems business is interested in selling. We gave the company a development subcontract that allows us to use the results of that development exclusively for a few years.

Primarily, we look to small companies for components. Almost by definition, a small startup company doesn't have the muscle, the talent, or the funding to work at the system level—they're not doing a whole communication system or a national network. But they *are* working on superconducting materials, or software for highly specialized database management, for example—projects that a half dozen people can get their arms around.

To come from outside, a technology has to be highly specialized but potentially high leverage, as in sensors; there's a tremendous market for very, very clever sensors. We started with a sensor company, Technar—helped them out, used their product. Now we own 80 percent of the company because almost two-thirds of the automobile manufacturers around the world want their sensors. Technar is at the point where they need the sensors mass-produced, but of course is not equipped to do it [without TRW investment].

■ *HT Business: So what you look for from a small startup are components to integrate into your systems?*
Mettler: Or niche technologies such as an advanced material.

■ *HT Business: Any plans to buy a semiconductor company?*
Mettler: I think it is unlikely. We are internally aggressive in that area, and have very large internal research and development projects. We are focusing on specialized applications that go to the very, very high-technology markets such as space and defense. We have obligations to provide some semiconductor production in the VLSIC (very large-scale integrated circuit) programs, but the program is not focused on mass production. We prefer to purchase our high-volume semiconductor needs. That's not to say we wouldn't seek companies involved in some advanced technology that's related to semiconductors.

■ *HT Business: Does high technology ever get too advanced to be of practical use?*
Mettler: There are many examples where technology is misapplied—the landscape is littered with companies that were too soon or too late with their products. We have an expression: "Technology push is a lot harder than market pull." In a fundamental sense, success requires knowing what the customer needs and wants. A beautiful example of that—which I hope we have timed correctly—is our gamble that automobile safety is going to become market driven. Safety technology in Mercedes, BMWs, Porsches, and other cars coming in from Europe is *way* ahead. That has not gone unnoticed by Chrysler and GM. For us, that translates into, "Know what the customer really wants and what technology can do, and then deliver it." We think technology can make an enormous contribution to safety.

■ *HT Business: Still, you're taking a tremendous gamble.*
Mettler: Well, it is a huge gamble, because we are the only company in the world that has assembled all the pieces into a system—advanced sensors, an airbag, seatbelts, and a microprocessor-based controller. We're prepared to offer this system to U.S. automakers because we manufacture it already in Europe. The challenge, then, is to persuade automobile manufacturers to buy from a systems-supply company. We must convince them that our technology is better, and that it will cost less because the system will be standardized.

■ *HT Business: Any hot new technologies to watch?*
Mettler: There is an exploding market in information systems. I don't think anyone can define how large it is. In the purely commercial information systems, we've taken what was a tiny internal development and created a new group, gathering up parts from different segments of the company and putting them together in a business that's more than doubled in the last two-and-a-half to three years. It's about a half-billion-dollar business this year, and it's rapidly growing. We expect there to be plenty of room for new products under that umbrella, so we will be pushing that [group] very much.

There's a whole package of information technologies that are pervasive, fast-growing, and critical for all product companies. These technologies use software, computers, telecommunications, and signal processing to handle information that controls the function of some device—a car engine, for example, or a steering system.

When we look across all of our sectors and groups, about 25 percent of our revenues come from such information systems. But if we look only at spacecraft, or at an electronic steering system for cars, increasingly a bigger and bigger chunk is software and electronics—in other words, information systems. When we looked at the development cost of a data-relay satellite, 40 percent was in software.

What makes information management so pervasive is its direct application to the products we sell, to the way we manufacture products, and finally, to our internal management systems. It cuts across all three.

Something that is equally exciting and pervasive is materials. There is a revolution on the way in advanced materials. At TRW, at universities, and elsewhere, we are working to create materials that don't occur in nature, enhancing those that do, and then using them in the mechanical aspects of products. I'm talking about plastic composites, ceramics, superconducting materials, organometallics—which are combinations of organic and physical elements—and materials that have properties that we just didn't know about.

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Mettler: There is a hierarchy of technology requirements that depend on what kind of business you're in. Some can't be served without the absolute highest technology available. But you really don't need the absolute best technology in every business; this jacket I'm wearing doesn't have to be made of the stuff the astronauts wear. We've cast our lot with high technology. I'm not suggesting everybody do that. ■

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NEW COMPANIES

COMPANY	BUSINESS OBJECTIVE	FINANCING	OFFICERS	OFFICERS' PREVIOUS POSTS
Intelligent Technology Group 115 Evergreen Heights Dr. Pittsburgh, PA 15229 (412) 931-7600	To develop artificial-intelligence software products for business and industry. Intelligent Technology acts as an umbrella group providing senior management, marketing, financial, and business-development assistance to all divisions of the company.	Company president provided seed capital	Larry K. Geisel, founder, president and CEO Paul V. Holey, v.p. of R&D Michael Chambers, executive v.p. business development	Carnegie Group, president and CEO Inference, chief scientist Carnegie Group, v.p. sales and marketing
Hi-Tech Venture Consultants 8 W. 40th St. New York, NY 10018 (212) 819-9500	To provide consultation to companies considering high-technology investments. Services include identifying emerging markets, helping companies plan marketing strategies, and arranging meetings between companies and potential investors.	Seed capital from founders	Robert A. Friedenberg, president/management Ralph L. Hensler, president/technology assessment	Shearson Lehman Brothers, senior vice-president Ebasco project manager
Taltec Computers 14455 N. Hayden Rd. Scottsdale, AZ 85260 (602) 998-8860	Provide systems to enhance and combine the capabilities of the PICK operating system (integrated relational database management system-RDBMS) and Unix operating system. The first product, Symetrix, offers office-automation, applications, and data entry.	51% owner Edge Computer; $600,000	Alfred J. Dei Maggi, president and CEO Ted Stofaros, v.p. PICK technology Jeff Nisler, chief engineer	Sequoia Systems, v.p. sales and marketing Altos Computer, manager, PICK software development Altos Computer, senior programmer
Special Technologies Texas Bank Building 225-25 1919 South Shiloh Rd. Garland, TX 75042 (214) 840-0867	Helps city, state, and other law-enforcement agencies sort through technologies available to them for surveillance. The company will provide information on each product and custom-develop accessories.	Privately held	Ron Spatafora, president	Texas Instruments, program-requirements manager
Carcel Telecommunications 18805 Cox Ave. Saratoga, CA 95070 (408) 374-0807	Providing access to multiple voice and data services for personal-computer users via standard phone lines. Services include MCI Mail, Dow Jones Information Services, energy information and meter-reading from Pacific Gas & Electric, and home banking.	Privately held	Gregg Carse, president	CWA Communications Products, president (current)
Campbell Communications 4132 Carambola Circle S., F-101 Coconut Creek, FL 33066 (305) 977-7246	A public-relations company for venture-funded, startup companies, emerging high-technology and biotechnology companies, hospitals, and medical-service companies.	Privately held	Douglas G. Campbell, founder and president	Thompson CGR Medical, director of corp. communications
Gazelle Microcircuits 2300 Owen St. Santa Clara, CA 95050 (408) 982-0900	A design and marketing company in the digital, gallium-arsenide VLSI (very large-scale integration) circuit business.	$900,000 split equally between Kliener, Perkins; Caulfield & Byers; and Hombrecht & Quist	Jerry R. Crowley, chairman and CEO David C. MacMillian, founder, v.p. marketing Andrew C. Graham, founder, v.p. engineering	Oki Semiconductor, founder, vice chairman, CEO GigaBit Logic, marketing GigaBit Logic, design chief
Omnirel 205 Crawford Ave. Leominster, MA 01453 (617) 534-5776	Making circuits that allow dissimilar semiconductors in one package to produce a functional circuit. The main market is military applications such as guidance and control systems for missiles, plus medical electronics and telecommunications.	$7.5 million from venture-capital groups; balance from state industrial revenue bonds	John F. Catrambone, president Terry Heng, executive v.p. Ross Henderson, director of product development	Unitrode, v.p. sales and marketing Unitrode, director of R&D Powercube, director of engineering
World ComNet 17310 Red Hill Rd., Suite 360 Irvine, CA 92714 (714) 250-1238	A global travel-reservations network that provides on-line service to individuals and travel agents. Tours and third-level airline (commuter carriers) seats can be reserved.	$500,000 from private sources; $5 million from private sale of stock to WCN Investments	Stephen J. Fryer, chairman and CEO George Wong, president Dick Hankins, v.p. reservations operations Alice Porson, v.p. sales	ACRO Corp., president Bechtel Corp., v.p. CCS, founder American Airlines, GE information systems

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EKMS 106 Inmon St. Cambridge, MA 02139 (617) 864–4706	Helps clients bring products to market by securing product licensing or software publishing agreements.	$300,000 from undisclosed private investors	Edward Kahn, president	Electronic Designs, publicity manager
Photonic Integration Research 1375 Perry St. Columbus, OH 43201	Research and development of technology to permit large-scale production of reliable and inexpensive optical components and devices.	$10 million from NTT (49%), Mitsubishi (41%), and Battelle (10%)	T. Miyoshita, president	NTT, in charge of research on optical communications
Knowledge Garden 473A Malden Bridge Rd. Nassau, NY 12123 (518) 766–3000	Create artificial-intelligence software for professional and business users. The software currently available will provide assistance to marketing, distribution, and support departments; it also performs word-processing and database functions.	Privately held	John Slade, president William Thompson, director of R&D Beverly Thompson, director of knowledge-based systems	Blackbaud MicroSystems, co-founder MicroExpert Systems, founder MicroExpert Systems, founder

JOINT VENTURES

COMPANY	COMPANY	PURPOSE	CONTACT
Adobe Systems	National Bureau of Standards (NBS)	To help establish an NBS electronic-publishing laboratory to be located at the U.S. Dept. of Commerce in Gaithersburg, MD. Will provide location for businesses and federal agencies to evaluate electronic-publishing needs.	Adobe Systems 1879 Embarcadero Rd. Palo Alta, CA 94303 (415) 852–0271
Allelix	Continental Pharma Cryason	To research heparinase, an enzyme used to restore blood-clotting ability and minimize risks associated with open-heart surgery and kidney dialysis.	Allelix, 6850 Gorewoy Mississauga, Ontario, Canada L4V 1P1 (416) 677–0831
McDonnell Douglas	Rolls-Royce British Aerospace	To develop a new Harrier II fighter aircraft with an updated vectared-thrust engine and advanced radar. The sale of the fighter will be proposed to the U.S. Marines and American allies.	McDonnell Douglas Box 516 St. Louis, MO 63166 (314) 234–7147
Cetus	Squibb	To develop new biotechnology-based products for cardiovascular, anti-inflammatory, and anti-infective markets, including anti-fungals and anti-virals. First product will be a human monoclonal antibody for septic shock.	Cetus 1400 53rd St. Emeryville, CA 94608 (415) 420–3300

CONTRACTS AWARDED

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Memory Metals 84 West Park Pl. Stamford, CT 06901 (203) 357–9777	NASA	$500,000	To research and develop joints and couplings for advanced composite materials using shape memory effect (SME) alloys for space vehicles and structures.
Imatron 389 Oyster Point Blvd. South San Francisco, CA 94080 (415) 583–9964.	U.S. Army Medical Research and Development Command	$2.1 million	To develop prototype of fast, portable, compact X-ray scanner. The focus is on a portable, filmless scanner that performs digital tomographic and scanned projection radiographic imaging in combat-zone medical facilities.
Software Productivity Solutions Research, Box 361697 Melbourne, FL 32936 (305) 773–6510	NASA, Small Business Innovation	$50,000	To create a software-development system to increase NASA's productivity in generating Ada application software through reusable software components.

AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Aracor 425 Lakeside Dr. Sunnyvale, CA 94086 (408) 733-7780	Defense Nuclear Agency	$1.5 million	To develop a nondestructive inspection system for checking electronic systems and advanced materials. Aracor will use computed tomography and luminography techniques to identify size and locate flaws within a material or structure.
Spire Patriots Park Bedford, MA 01730 (617) 275-6000	U.S. Department of Energy	$50,000	To develop electrically conductive polymers by ion implantation on several types of nonconducting polymeric sheet. To assess the feasibility of treating large areas and production quantities using present ion-implantation equipment.
Eaton, AIL Division Commack Rd. Deer Park, NY 11729 (516) 595-5741	U.S. Army	$4.9 million	To develop an integrated, modular radar system as part of a multiple-sensor, elevated-target acquisition system. Will also provide engineering assistance, and support a 1988 technical demonstration.
Giddings & Lewis 142 Doty St. Fond du Lac, WI 54935 (414) 921-9400	Hezhong-Carrier Air Conditioner Equipment Co. Ltd	$2.7 million	To provide a vertical turning lathe and support equipment including tooling, fixturing, and a drill-paint grinder for three machining centers. The latest payoff of a strategy by Giddings & Lewis to cultivate the Chinese market for machine tools.
GTE Fiber Optic Products 2401 Reach Rd. Williamspart, PA 17701 (617) 777-1900	Nynex Enterprises	$250,000	Applies to GTE's Elastomeric glass-tube products, fiber-optic components, and cleaving tool and installation kit.
Lockheed-Georgia Dept. 840-02, Zone 18 Marietta, GA 30063 (404) 424-2701	Warner Robbins Airlogistics Center	Valued at $608,000	To develop a preliminary design for a modernized flight station for the C-141B Star Lifter fleet, and to study a means of updating the flight stations of C-141Bs operated by the U.S. Air Force Military Airlift Command (MAC).
Harris, Farinon Division 1691 Bayport Ave. San Carlos, CA 94070 (415) 594-3000	San Diego Gas and Electric Co.	Not disclosed	To design, engineer, and install a digital microwave and lightwave system for voice and data communications throughout San Diego County and Orange County, and to upgrade the existing analog communications system.
Ericsson, Information Systems Div. 730 International Pkwy. Richardson, TX 75081 (214) 669-9900	Oklahoma State University	$6.1 million	For an integrated voice-data switching system to accommodate more than 11,452 stations in administration and student housing. The system will support the anticipated increase of personal computers and terminals on campus.
U.S. Department of Energy 550 Second St. Idaho Falls, ID 83401 (208) 526-1317	GA Technologies, Westinghouse, Babcock & Wilcox, Nuclear Packaging, Nuclear Assurance	Not disclosed	To design and develop prototypes for casks required to ship spent nuclear fuel under provisions of the Nuclear Waste Policy Act of 1982.
Ball Box 1062 Boulder, CO 80306 (303) 939-4101	U.S. Air Force	$43 million	To build a research spacecraft that demonstrates technology for the remote detection and inspection of nuclear material in space.
Avanti Communications Aquidneck Industrial Park Newport, RI 02840 (401) 849-4660	Comsat Corp.	$1.1 million, first phase	To provide the UltraMux high-speed communications networking equipment, adopted for Voice of America to broadcast news, music, and presidential statements overseas.
M/A-Com Telecommunications 11717 Exploration Lane Germantown, MD 20874	Computer Power	Not disclosed	To supply and install M/A-Com Telecommunications' Integrated Satellite Business Network to bypass conventional non-satellite phone-company equipment.
Interleaf 10 Canal Park Cambridge, MA 02141 (617) 577-9800	Boeing Computer Services	$1.4-million subcontract	To provide electronic-publishing software for NASA's space station program.
Tracor Aerospace 6500 Tracor Lane Austin, TX 78725 (512) 929-2271	General Electric	$28 million	Subcontract to develop and flight-test an advanced chaff system and associated development hardware for the Minuteman III missile.

MERGERS

COMPANY	BUSINESS	COMPANY	BUSINESS	NEW NAME
Symantec 10201 Torie Ave. Cupertino, CA 95014 (408) 253-9600	Software	Living Videotext 117 Easy St. Mountain View, CA 94035 (415) 964-6300.	Outline processors	Living Videatext becomes a division of Symantec but retains its name.
Quest Blood Substitute 320 Fisher Bldg. Detroit, MI 48202 (313) 873-0200	Blood substitutes	Hunt Research 320 Fisher Bldg. Detroit, MI 48202 (313) 873-0200	Research	Quest Blood Substitute

ACQUISITIONS

BUYER	BUSINESS	COMPANY ACQUIRED	BUSINESS	AMOUNT
Borland International 4584 Scotts Volley Dr. Scotts Valley, CA 95066 (408) 438-8400	Software	Ansa Software 1301 Shoreway Rd. Belmont, CA 94002 (415) 595-4469	Software	$38 million
Lotus Development 50 Commercial Ave. Cambridge, MA 02141 (617) 577-8500	Software	Computer Access 26 Brighton St. Belmont, MA 02178 (617) 484-2412	Software	Not disclosed
Flextronics 35325 Fircrest St. Newark, CA 94560 (415) 794-3539	Manufacturer for computer and telecommunications industry	Vortech 197 U.S. Route 1 Scarborough, ME 04074 (207) 883-9591	Independent test lab	Not disclosed
Contel ASC 1801 Research Blvd. Rockville, MD 20850 (301) 251-8300	Satellite telecommunications	Equitorial Communications Co. 189 N. Bernardo Ave. Mountain View, CA 94043 (415) 969-9500	Satellite telecommunications	$38 million
Excelan 2180 Fortune Dr. San Jose, CA 95131 (408) 434-2226	Local-area networks	Kinetics 2500 Camino Diablo, Suite 110 Walnut Creek, CA 94596 (415) 947-0998	Apple networking products	$7-8 million (est.)
Booz, Allen & Hamilton 101 Park Ave. New York, NY 10178 (212) 697-1900	Management and technology consultants	CSP International 24 East 21st St. New York, NY 10010 (212) 505-2200	Telecommunications and information-technology consultants	Not disclosed
Data I/O Box 97046 Redmond, WA 98073 (206) 881-6444	Computer-aided design systems	Endot 1001 Cedar Ave. Cleveland, OH 44106 (216) 229-8900	Design-software supplier	$5.8 million (est.)
Sarbus 50 E. Swedesford Rd. Frazer, PA 19355 (215) 296-6000	Computer maintenance	Pacific Computer 279 Sinclair Frontage Rd. Milpitas, CA 95035 (408) 263-3033	Computer maintenance	Not disclosed
Austec 1740 Technology Dr. San Jose, CA 95110 (408) 279-5533	Cobol network and software products	Ryan-McFarland 609 Deep Valley Dr. Rolling Hill Estates, CA 90274 (213) 541-4828	Cobol and Fortran compilers	Not disclosed
Biotechnica Agriculture 7300 W. 110th St. #540 Overland Park, KS 66210 (913) 661-0611	Biotechnology	McAllister Seed Co. Highway 218, Box 28 Mount Pleasant, IA 52641 (813) 385-2259	Seeds	Not disclosed

Printers for Home, Office

OFFICE PRODUCTS

Complete Answering Machine board. This coprocessor board for Microsoft MS-DOS-based personal computers provides personal voice mail, advanced message handling, and basic telephone-answering-machine functions. $349. The Complete PC, 521 Cottonwood Dr., Milpitas, CA 95035. (408) 434–0145. *Circle 1.*

DL8800 dot-matrix printer. Prints many types of forms and reads/writes standard U.S. bar codes or identification marks as large as 10 bytes. $4,400 with Centronics interface. Fujitsu America, 3055 Orchard Dr., San Jose, CA 95134. (408) 946–8777. *Circle 2.*

Desnet local-area network. Working with Zenith 100, 150, and 240 microcomputers, this network operates at 2 megabits/second to accommodate up to 250 nodes. $495/node. NTI Group, 3271 Kifer Rd., Santa Clara, CA 95051. (408) 739–2180. *Circle 3.*

Lynx Laser/VT600 typographic proof system. Configured around a laser printer with 600-dot/inch resolution, this package makes plain-paper copies of typeset material less expensively than machines that use photography paper or film. Software and board: $6,995. US Lynx, 853 Broadway, New York, NY 10003. (212) 673–3210. *Circle 4.*

MZ-4 page controller. Provides a one-way voice-paging connection between a phone system and as many as four zones of a paging/background-music system. $385. Gordon Kapes Inc., 5520 W. Touhy Ave., Skokie, IL 60077. (312) 676–1750. *Circle 5.*

Model L1012 laser printer. Prints 12 pages/minute; offers 18 fonts with nine typefaces in portrait and landscape modes. The toner has a life of 2,000 pages; developer and drum, 15,000 pages; optical filter and fusion unit; 45,000 pages. $3,495. Printronix Inc., 17500 Cartwright Rd., Irvine, CA 92713. (714) 863-1900. *Circle 6.*

Model VT600 laser printer. Includes eight resident fonts, symbols, more than 750 font widths and set sizes, system utilities, and customization modules. $18,750; package including software and board: $25,705. US Lynx, 853 Broadway, New York, NY 10003. (212) 673-3210. *Circle 7.*

NP-112 desktop copier. Prints 11 copies/minute in black, brown, or blue; reduces and enlarges original; collates. $1,995. Canon, Reprographic Products, 1 Canon Plaza, Lake Success, NY 11042. (800) 652-2666. *Circle 8.*

Page-Vu slide enlarger. Attaches to circular-tray projectors to show slides. $199. Visual Horizons, 180 Metro Park, Rochester, NY 14623. (716) 424-5300. *Circle 9.*

Tokenstar 4012/4024 communications link. Sends data at high speed (1 megabit/second) without affecting telephone conversations. $1,995 for Model 4012, $3,495 for Model 4024. Telegence Corp., 5655 Lindero Canyon Rd., Suite 722, Westlake Village, CA 91326. (818) 707-3200. *Circle 10.*

COMPUTER HARDWARE

ALR 386–2 IBM-compatible computer. Has 1 megabyte of 32-bit RAM (expandable to 2 megabytes) a 1.2-megabyte floppy-disk drive; serial and parallel ports. $1,990. Advanced Logic Research, 10 Chrysler, Irvine, CA 92718. (714) 581-6770. *Circle 11.*

Color/Mono video adapter. Supports IBM Color Graphics Adapter and IBM Monochrome Display Adapter cards. Provides graphic resolutions as fine as 640×200 pixels in two colors and 320×200 pixels in four colors. $149. STB Systems Inc., Box 850957, 1651 N. Glenville, Richardson, TX 75085. (214) 234-8750. *Circle 12.*

Das-20 analog and digital I/O board. IBM-compatible; has a 12-bit analog-to-digital converter and 2-megabyte RAM. $1,495. Metrabyte Corp., 440 Myles Standish Blvd., Taunton, MA 02780. (617) 880-3000. *Circle 13.*

HK68/M120 Multibus I single-board computer. Based on the 68020 microprocessor for 25-MHz central processing. Accommodates 4 megabytes of on-board dynamic RAM and provides an ANSI-compatible small computer system interface. From $1,195. Heurikon Corp., 3201 Latham Dr., Madison, WI 53713. (608) 271–8700. *Circle 14.*

ICON diskless workstation. An IBM PC-compatible station made for students working in multiple-user classrooms. Offers 1-megabyte memory, speech synthesis, and color graphics. $1,895. Unisys, Township Line and Union Meeting Rd., Blue Bell, PA 19422. (215) 542–4011. *Circle 15.*

Ideatape tape drive. Holds 60 megabytes; compatible with IBM computers. Allows multiplex backups on a single tape. Internal configuration: $1,775; external: $2,395. Ideassociates, 29 Dunham Rd., Billerica, MA 01821. (617) 663–6878. *Circle 16.*

LP-75 laser printer. Provides 1.5 megabytes of memory and prints six pages/minute. Nine resident fonts and a 150-page output bin. Compatible with Laserjet Series II printer. $2,595. Acer Technologies, 401 Charcot Ave., San Jose, CA 95131. (408) 922–0333. *Circle 17.*

Z-183 portable personal computer. Has a 10-megabyte hard disk, a 640-kilobyte RAM, a 10½-in. diagonal liquid-crystal display, and a 5¼-in. floppy-disk drive. This computer runs two to five hours on one battery charge. $3,499. Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025. (312) 699–4800. *Circle 18.*

1010XT IBM-compatible computer. Offers componentless motherboard and an eight-slot, mainframe-style open bus, featuring automatic memory size, on-screen diagnostics, and an IBM PC/AT-style keyboard. Also has a single floppy-disk drive, a 20-megabyte hard drive, and monitor. $1,429. Innovation Computer, 1325 Juniper St., Cleveland, WI 53015. (414) 693–3416. *Circle 19.*

COMPUTER SOFTWARE

Decision Pad productivity software. This interactive decision-making environment for the IBM PC combines elements of

spreadsheets and rational-decision theory. Supports such common business situations as personnel selection and review. $99. Apian Software Inc., Box 1224, Menlo Park, CA 94026. (800) 237-4565. *Circle 20.*

HEADLINER database. Helps writers find and modify expressions to generate headlines, jingles, and slogans. $495. Salinon Corp., Box 31047, Dallas, TX 75231. (214) 692–9091. *Circle 21.*

HPGL plotting utility. On IBM AT or compatible personal computers, this software converts HPGL commands into Versaplot commands for output on Versatec plotters. $100. Versatec, 2710 Walsh Ave., Santa Clara, CA 95051. (800) 538–6477; in CA, (800) 341–6060. *Circle 22.*

MacScheme+Toolsmith software developer. For Apple computers, offers a selective linker, high-level objects for windows and menus, and a library of data definitions and traps. $395. Semantic Microsystems Inc., 4470 S.W. Hall St., Suite 340, Beaverton, OR 97005. (503) 643–4539. *Circle 23.*

MOVE animation program. Lets users manipulate objects with realistic motion; can define as many as 400 objects, then play back the sequence. Price not available. Interactive Machines Inc., 26588 Agoura Rd., Calabasas, CA 91302. (818) 707–1880. *Circle 24.*

P11 animation program. Using an IBM PC or compatible, a programmer/artist can create as many as 999 frames of vector and raster images for animation. $59.95. Russell D. Hoffman, Box 5185, Bridgeport, CT 06610. (203) 366–0258. *Circle 25.*

PCKey utility. Converts keyboards to Dvorak layout. Runs on IBM PC/XT/ATs and compatibles. $20. Freelance Communications, Box 1895, Upland, CA 91785. (818) 963-3703. *Circle 26.*

PCOX/TWO micro/mainframe software. Allows one host-printer session concurrently with another printer or personal-computer session. $200 to $400. CXI Inc., 1157 San Antonio Rd., Mountain View, CA 94043. (800) 225–7269; in CA, (415) 969–1999. *Circle 27.*

Personal Financial Planner. A spreadsheet that plans taxes and real estate; analyzes investment, insurance, disability, and retirement options; and handle amortization schedules. $750. TaxCalc Software Inc., 4210 W. Vickery, Fort Worth, TX 76107. (800) 527–2669; in TX, (817) 738–3122. *Circle 28.*

Quickviews accounting software. Programs include General Ledger, which runs in color and prints mailing labels, cards, invoices, checks, and reports. $149.95. Micro Computer Business Services, Dept. M-226, 12703 Veterans Memorial Dr., Houston, TX 77014. (800) 367-6227; in TX, (713) 444-6269. *Circle 29.*

Thought Problems math worksheet. This software lets teachers first determine the level of difficulty, then generate an unlimited number of thought-problem worksheets for classroom assignments. $49.95. Friend-Lee Software, 6041 West View Dr., Orange, CA 92669. (714) 771–1678. *Circle 30.*

WinGraph business graphics. A software package that creates business graphs and charts in nine styles. $99.95. Media Cybernetics, 8484 Georgia Ave., Silver Spring, MD 20910. (800) 426–4256. *Circle 31.*

INDUSTRIAL/MANUFACTURING

Acu-Min inspection light. Reaches hard-to-see areas. $19.95. Moody Tools Inc., Box 230, East Greenwich, RI 02818. (800) 223–9036; in RI, (401) 885–0911. *Circle 32.*

CADJET command-speed booster. Speeds command input as much as three times on the CADKEY 3-D engineering system for personal computers. $339. HLB Technology, Box 527, Blue Ridge, VA 24064. (703) 977–6520. *Circle 33.*

Class material-analysis system. Helps engineers predict the properties of laminated composite materials and perform point-stress analysis. Runs on an IBM PC. $295. ASM International, Metals Park, OH 44073. (216) 338–5151. *Circle 34.*

Cyclodextrin. A chemical that forms host-guest inclusion complexes and modifies physical/chemical properties of the guest molecule. Applicable in the food, pharmaceuticals, fragrance, health, cosmetics, and agrichemical industries. Price varies with use. American Maize-Products Co., 1100 Indianapolis Blvd., Hammond, IN 46320. (800) 348-9896; in IN, (219) 659-2000. *Circle 35.*

Design Advisor. An artificial-intelligence system that emulates expert knowledge in designing computer microcircuits. Available in 1988. NCR Corp., Microelectronics Div., 2001 Danfield Court, Fort Collins, CO 80525. (303) 223–5100. *Circle 36.*

FGS-4500 3-D system. Provides modeling capabilities for artists; uses a Sun workstation. $150,000. Broadcast Television Systems, Box 30816, Salt Lake City, UT 84130. (801) 972–8000. *Circle 37.*

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September, 1987

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5	35	65	95	125	155	185	215	245	275	305	335	385
6	38	88	96	128	158	188	218	246	278	308	338	388
7	37	87	97	127	157	187	217	247	277	307	337	387
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18	48	78	108	138	168	198	228	258	288	318	348	378
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21	51	81	111	141	171	201	231	281	291	321	351	381
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24	54	84	114	144	174	204	234	264	294	324	354	384
25	55	85	115	145	175	205	235	285	295	325	355	385
28	58	88	118	148	178	208	238	288	298	328	358	388
27	57	87	117	147	177	207	237	287	297	327	357	387
28	58	88	118	148	178	208	238	288	298	328	358	388
29	59	89	119	149	179	209	239	289	299	329	359	389
30	60	90	120	150	180	210	240	270	300	330	380	390

HTBAS

programs: Geodraw for 2-D drafting; Model Solution for linear static, dynamic, and potential flow analysis; Optimization, a structural-analysis module that automates redesign tasks. For Sun-3 workstations. $1,500 to $3,800. SDRC, 2000 Eastman Dr., Milford, OH 45150. (513) 576–2400. *Circle 41.*

InGaAs detector arrays. For infrared-detection applications including temperature sensors, motion detectors, and eyesafe range-finders. Price varies with customization. Epitaxx Inc., 3490 U.S. Route 1, Princeton, NJ 08540. (609) 452–1188. *Circle 42.*

JTFA/JTFAF amplified accelerometer. Two models provide high-level output and accurate measurements of acceleration. Both withstand overloads of five times the full output without damage. Less than $600. Sensotec Inc., 1200 Chesapeake Ave., Columbus, OH 43212. (614) 486–7723. *Circle 43.*

LED exit signs. Replace bulb-illuminated signs. $165.63 to $215.63. Don Gilbert Industries Inc., Box 2188, Jonesboro, AR 72402. (800) 826–9041. *Circle 44.*

Link2 CV interface. Integrates Calay CAD systems with Computervision workstations. $10,000. Calay Systems Inc., 2698 White Rd., Irvine, CA 92714. (714) 863–1700. *Circle 45.*

MVP 2000 manufacturing inspector. Computerized; provides faster applications speed, greater programming capacity, and font- and character-quality verification for discrete-parts inspection. Under $20,000. Itran Corp., 670 N. Commercial St., Manchester, NH 03101. (603) 669–6332. *Circle 46.*

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FutureDesigner design-entry system. Offers graphic menus, schematic capture, behavioral-logic specification, interactive design verification, and logic synthesis. $11,500 with a 32-bit, 2-megabyte coprocessor. FutureNet Corp., 9310 Topanga Canyon Blvd., Chatsworth, CA 91311. (818) 700–0691. *Circle 38.*

GaAlAs infrared-emitting diode. Provides 1.7 times the radiant output of gallium-arsenide equivalent devices. $10.63 each in quantities of 1,000. TRW, Electronic Components Group, Optoelectronics Division, 15 W. Crosby Rd., Carrollton, TX 75006. (214) 323–2200. *Circle 39.*

Go-Elan programmer. Transforms engineering specifications into machine language, providing graphic verification and correction. The programmer is available in five computer languages. $18,000 to $30,000. Centech, 511 Zenith Dr., Glenview, IL 60025. (312) 299–6788. *Circle 40.*

I-DEAS mechanical engineering. Three programs: Geodraw for 2-D drafting; Model Solution for linear static, dynamic, and potential flow analysis; Optimization, a structural-analysis module that automates redesign tasks. For Sun-3 workstations. $1,500 to $3,800. SDRC, 2000 Eastman Dr., Milford, OH 45150. (513) 576–2400. *Circle 41.*

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M3095A/B large-document image scanner. Scans images and electronically stores them for computer design and engineering tasks. M3095A: $6,310; M3095B: $5,185. Fujitsu America Inc., 3055 Orchard Dr., San Jose, CA 95134. (408) 946–8777. *Circle 47.*

Model AD767 digital-to-analog converter. Works with 16-bit microprocessors and digital signal processors. $10.95 each in lots of 100. Analog Devices, Box 9106, Norwood, MA 02062. (617) 329–4700. *Circle 48.*

Model 901 security system. Automatic system for fiber-optic communications networks; detects tampering or broken cables. $8,500+. Pilkington Communications Systems Inc., 65 Moreland Rd., Simi Valley, CA 93065. (805) 522–3333. *Circle 49.*

Models 227SS/2276S microwave noise testers. Offer simplified approach to microwave noise-figure measurements. $46,765 and $61,745. Eaton Corp., 5340 Alla Rd., Los Angeles, CA 90066. (213) 822–3061. *Circle 50.*

Optical data-storage cartridge. Protects from dust and abrasion. Prices vary. Opticord Inc., 3701-A Berdnick, Rolling Meadows, IL 60008. (312) 705–1952. *Circle 51.*

Route Engine III routing accelerator. This software uses a rip-up and reroute algorithm to handle fine line routing, multiple traces between pads, pin-grid arrays, or unique design rules. $89,500. Cadnetix Corp.,

5757 Central Ave., Boulder, CO 80301. (303) 444–8075. *Circle 52.*

Series 1000 factory-automation system. This distributed numerical control and communications system provides a communications link to the shop floor using an IBM PC XT/AT or compatible computer and the Unix operating system. Starts at $7,500. CAD/CAM Integration, 80 Winn St., Woburn, MA 01801. (617) 933–9500. *Circle 53.*

Slo-Syn servo motors. Used in robots, transfer stations, pedestals, process controls, actuators, indexers, machine tools, packaging and textile equipment. $3,900 to $8,200. Superior Electric Co., 383 Middle St., Bristol, CT 06010. (203) 582–9561. *Circle 54.*

TGA-300 toxic-gas adsorber. Removes hazardous emissions from semiconductor process effluent. $9,987 to $18,682. Emcore Corp., 111 Corporate Blvd., S. Plainfield, NJ 07080. (201) 753–1311. *Circle 55.*

TI-50ES CCD camera. Has electronic shutter; suited for surveillance. $375. NEC America, Broadcast Equipment, 1255 Michael Dr., Wood Dale, IL 60191. (312) 860–7600. *Circle 56.*

TMC 8 torque-assurance system. The system monitors, controls, and records data on electric or pneumatic nut runners. From $12,000. Tech-S Inc., 12997 Merriman Rd., Livonia, MI 48150. (800) 228-3247; in MI, (313) 425–9800. *Circle 57.*

UNIMOD 3-D modeling system. Generates solids for analysis and manufacturing systems; integrates with the company's Encographics CAD/CAM modules. $5000 to $8000. Encode Inc., 12 Cotton Rd., Nashua, NH 03063. (603) 882–4666. *Circle 58.*

947/948 Auto-Test-1 data logger and control. Links helium-leak detectors to an IBM-compatible computer using Lotus 1-2-3 or dBase III. $395. Varian Associates Inc., 121 Hartwell Ave., Lexington, MA 02173. (617) 861–7200. *Circle 59.*

CONSUMER PRODUCTS

CD Saver. This device rescues scuffed or scratched CDs. $9.95. Buff Stuff Inc., Box 43128, Upper Montclair, NJ 07043. (201) 746–4316. *Circle 60.*

CMS 8000/S cellular telephone. Supports six base stations and 138 voice channels; additional stations and channels can be added in modular blocks. Price not available. Ericsson, 730 International Parkway, Richardson, TX 75081. (214) 669–9900. *Circle 61.*

Heathkit SB-1000 radio linear amplifier. Produces 850- to 1,000-watt output; has fan, power supply, and adjustable load controls. $73.95. Heath Co., Box 1288, Benton Harbor, MI 49022. (616) 982–3200. *Circle 62.*

Informer CB radios. Two models, INFO CB-1 and CB-2, use phase-lock loop circuitry to transmit and receive on 40 channels. $69.95 and $159.95. Regency Electronics Inc., 7707 Records St., Indianapolis, IN 46226. (312) 372–7090. *Circle 63.*

K-112 cassette deck. Has a three-head, two-motor system, Dolby HX-Pro, Dolby B and C noise reduction, and remote control. $500. Luxman, 19145 Gramercy Place, Torrance, CA 90509. (213) 326–8000. *Circle 64.*

PV-C66A VHS camcorder. This camera weighs 4.4 lbs. and records for periods as long as two hours and 40 minutes. Offers automatic focus, and power zoom. Price not available. Pentax, 35 Inverness Dr. East, Englewood, CO 80112. (303) 799–8000. *Circle 65.*

COMPANY INDEX

The following is a list of companies mentioned in this issue of HIGH TECHNOLOGY BUSINESS, and the pages on which they appear.

Slides, Stereo and Savings

OFFICE

PC Fax Lets You Skip the Printout

FACSIMILE (FAX) transmitters for personal computers are becoming more widespread as low-priced entries make such transmission available to a wider variety of users who want the convenience of sending documents directly from their computers. The first such entry, JT Fax from Asher Technologies, costs $395 for an internal board; an external, portable version sells for $495.

So far, other fax boards for personal computers aim at the high end of the market, with prices from $1,000 to $1,500. Such boards are available from Datacopy, EIT, Gamma, GMS, LightSpeed, OAZ, and Panasonic. The Asher model transmits data about half as fast as other units, but Asher claims other features match or even rival higher-priced models. For instance, JT Fax stores graphic data such as logos and signatures for addition to letters.

All computer fax machines let users transmit copies of stored files, scanner input, or data directly from the screen. At the receiving end, where transmissions come in as a printout on conventional fax machines, print quality is generally higher because the original document is sent directly from digital form, rather than being scanned from a page and converted to digital format.

Such fax devices also accept and store data in the host personal computer for printout on a conventional printer. Other features include scheduling and directory systems, scanning, zooming, and transaction logs.

Asher Technologies is located at 1009-I Mansell Rd., Roswell, GA 30076, (404) 993-4590.

CAR

Amplifier Optimizes Car Stereos

PLUG-IN amplifiers, customized for a specific car, now give motorists optimal sound from car stereo systems. The amplifiers use microprocessor technology—computer chips—to adapt to the particular environment inside dozens of car models.

Previously, the only way to get custom-tuned sound—if you happened to buy a higher-priced car that offered such an option—was to order a built-in sound system such as GM Delco/Bose, Ford/JBL, or Chrysler/Infinity. These factory-installed setups match the interior acoustics of specific car models.

West Germany's Blaupunkt takes the same approach with its Parametric Sound Amplifier, which tailors add-on sound systems to any of 83 car makes and models. The amplifier uses a different plug-in module for each model. Each module contains electronic circuitry that adjusts the amplifier's sound output to the car, taking into account such factors as interior volume, the location of seats, and the sound-absorption characteristics of upholstery.

The product can be added to existing car stereos or installed with a new system. The suggested price is $210.

Microprocessor helps customize amplifier for your car's interior

STEVEN MARK NEEDHAM

GRAPHICS

Slides Perk Up Speeches

A NEW SERVICE for business speakers converts computer graphics and alphanumeric displays into slides and transparencies overnight—or even faster, if necessary. The company, Brilliant Image, claims that its slides have higher resolution than those from desktop slide-making machines (4,000 lines of resolution compared to 2,000).

BRILLIANT IMAGE

Service enhances slides

Unlike conventional desktop slide makers, which leave film developing to the user, the service delivers ready-to-use slides or transparencies. Computer displays can be sent to the company's office by modem or on disk. Slides arrive the next day. The standard, 24-hour service costs $10 per reproduction.

Brilliant Image accepts graphics from such software as Picture-It, Lotus 1-2-3, Symphony, Freelance Plus, Graphwriter, Video Show, PC-Slide, and Microsoft Chart. The service operates from 141 West 28th Street in New York; it plans to open offices in other cities as well. The phone number is (212) 736-9661. ■

BREAKTHROUGH:
HELPING COMPUTER PROGRAMMERS MAKE FAST AND STEADY PROGRESS.

Until now, manual skills were a big part of writing complicated computer programs. They required a major investment in time, effort and money—and days of boredom for the applications designer.

McDonnell Douglas information systems specialists developed a way to end the dull, turtle-speed tedium formerly necessary for good programs. Their software maps out the best program path and selects routine computer instructions.

The result is a working program that emerges with hare-like speed and is ready to use, allowing application systems designers to fully concentrate on the special characteristics of the project.

This breakthrough is called ALL—Application Language Liberator. Designers like it because it lets them try out ideas in prototype programs, quickly and easily, selecting only the best. Managements like it because it's faster, cheaper and yields better results.

We're making breakthroughs that add value and quality to information systems serving the people of the world.

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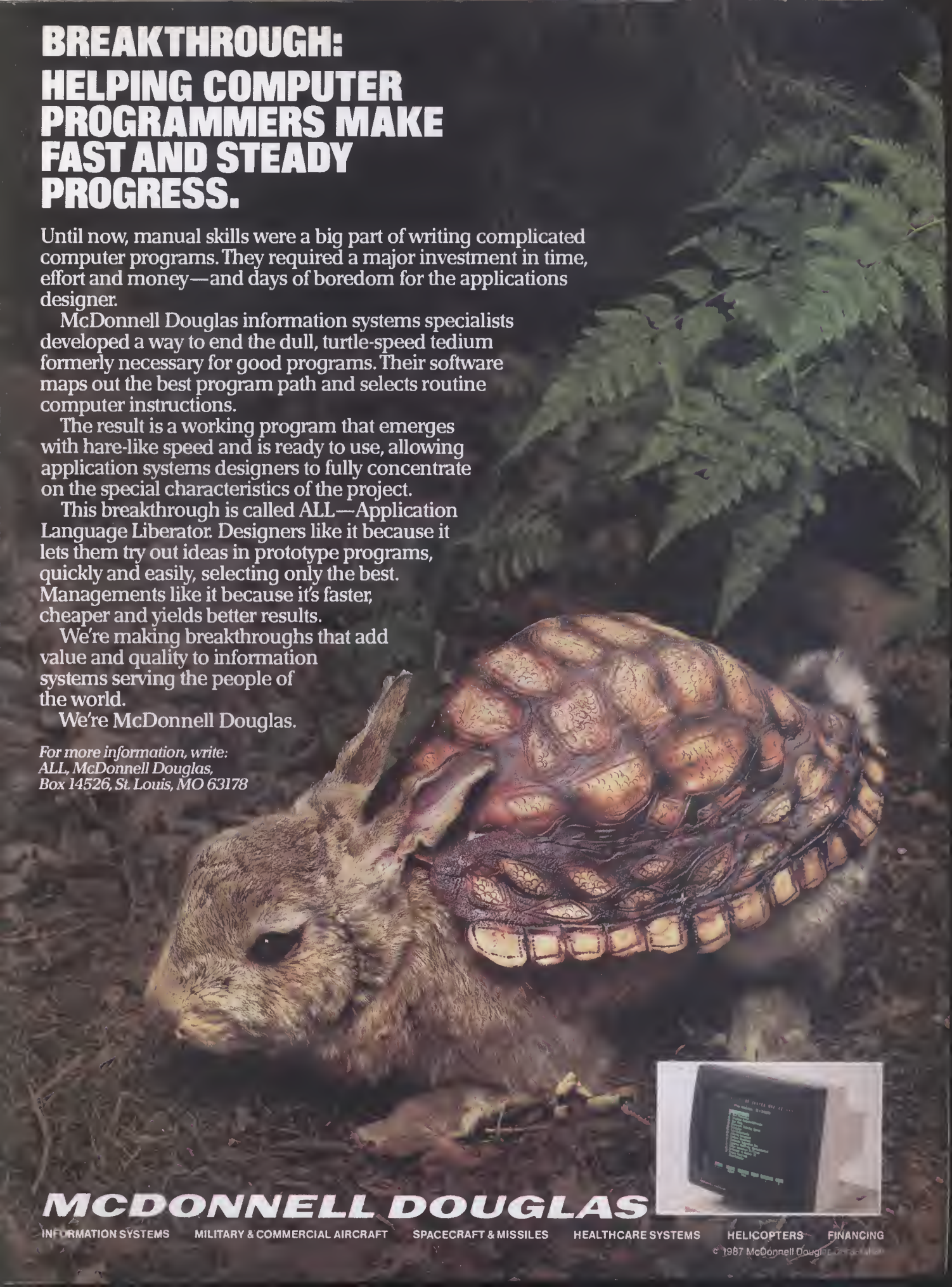
Box 14526, St. Louis, MO 63178



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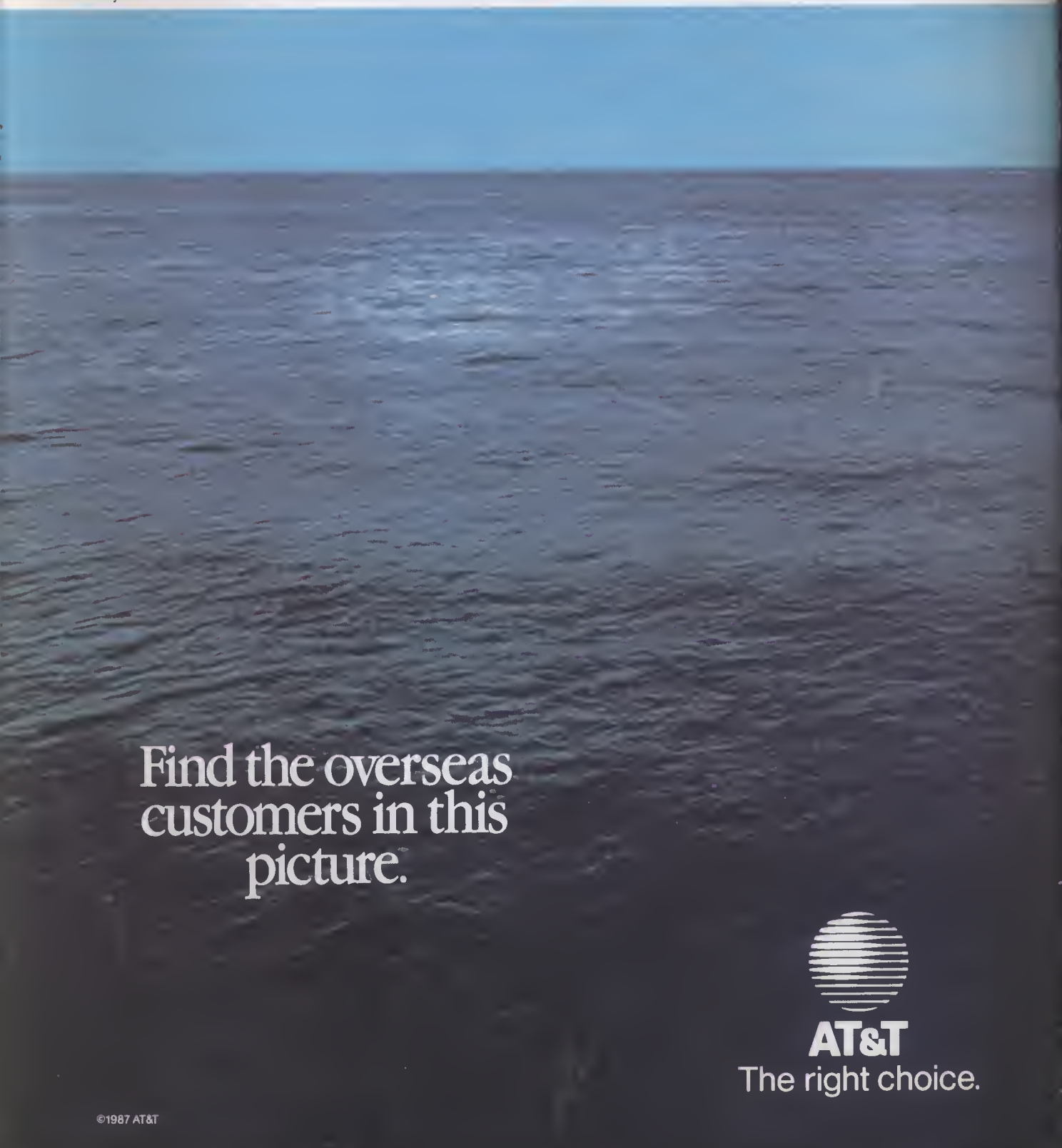

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